Lessons from Projects and Programs to Promote Improved Rainwater and Land Management in the Blue Nile (Abay) River Basin, Ethiopia

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Volume 1: Main Report

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Acronyms

Acronym	**Full name**
ADA	Amhara Development Association
ADLI	Agricultural Development-Led Industrialization
AE	Area Enclosure
AFfDB	African Development Bank
AHI	African Highlands Initiative
AMAREW	Amhara Micro-Enterprise Development, Agricultural Research, Extension and Watershed Management Project (USAID)
ANRS	Amhara National Regional State
ARARI	Amhara Regional Agricultural Research Institute
ARBO	Abay River Basin Organization
ARDO	Agriculture and Rural Development Offices
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASSP	Agricultural Sector Support Project
ATVET	Agriculture Technical and Vocational Education and Training
AWM	Agricultural Water Management
BDC	Basin Development Challenge
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (German Federal Ministry for Economic Cooperation and Development)
BoA	Board of Agriculture
BoARD	Board of Agriculture and Rural Development
BoWRD	Board of Water Resources Development
CAADP	Comprehensive Africa Agricultural Development Program
CBI	Community Based Institution
CBINReMP	Community-Based Integrated Natural Resources Management Project
CBPWD	Community Based Participatory Watershed Development
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture (Spanish acronym)
CIDA	Canadian International Development Agency
CIMMYT	International Maize and Wheat Improvement Center
CPWF	Challenge Program on Water and Food
CRS/E	Catholic Relief Services-Ethiopia
CWMO	Community Watershed Management Organization
CWP	Crop Water Productivity
CRDA	Christian Relief and Development Association
DA	Development Agent
DfID	Department for International Development (UK)
EARO	Ethiopian Agricultural Research Organization
EDRI	Ethiopian Development Research Institute
EEPFE	Environmental Economics Policy Forum for Ethiopia
EFAP	Ethiopian Forestry Action Program
EHRS	Ethiopian Highland Reclamation Study
EIA	Environmental Impact Assessment
EIAR	Ethiopian Institute of Agricultural Research
ENSAP	Eastern Nile Subsidiary Action Program
ENTRO	Eastern Nile Technical Regional Office
EPA	Environmental Protection Agency
EPLAUA	Environment Protection and Land Administration and Use Authority
ESIF	Ethiopia Strategic Investment Framework

ESSP	Ethiopia Strategy Support Program
ETB	Ethiopian Birr
EWNRA	Ethiopia Wetlands and Natural Resources Association
EWUAP	Efficient Water Use for Agricultural Production
FAO	Food and Agriculture Organization of the United Nations
FDRE	Federal Democratic Republic of Ethiopia
FfW	Food for Work
FSS	Forum for Social Studies
FTC	Farmers Training Center
GEF	Global Environmental Fund
GIS	Geographical Information Systems
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
HDI	Human Development Index
IASC	Inter-Agency Standing Committee
ICRAF	International Center for Research in Agro-forestry
ICARDA	International Center for Agricultural Research in Dry Areas
ICRISAT	International Crop Research Institute for Semi-Arid Tropics
IDE	International Development Enterprises
IDR	Institute of Development Research
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
INRM	Integrated Natural Resources Management
IPMS	Integrated Productivity and Market Support
IWM	Integrated Watershed Management
IWMI	International Water Management Institute
IWRM	Integrated Water Resources Management
JICA	Japanese International Cooperation Agency
LLPPA	Local Level Participatory Planning Approach
LSI	Large scale irrigation
LWP	Livestock Water Productivity
masl	Meters above sea level
M&E	Monitoring and Evaluation
MDG	Millennium Development Goal
MERET	Managing Environmental Resources to Enable Transitions
MoA	Ministry of Agriculture
MoARD	Ministry of Agriculture and Rural Development
MoFED	Ministry of Finance and Economic Development
MoWR	Ministry of Water Resources
MUS	Multiple Water Use Services
NAP	National Action Plans
NAPA	National Adaptation Program of Action
NBI	Nile Basin Initiative
NCCR	National Center of Competence in Research
NELSAP	Nile Equatorial Lakes Subsidiary Action Program
NGO	Non Government Organization
NMA	National Meteorological Agency
NRM	Natural Resources Management
ODI	Overseas Development Institute
ORDA	Organization for Rehabilitation and Development of Amhara
OSSREA	Organization for Social Science Research in Eastern and Southern Africa

PADETES	Participatory Demonstration and Training Extension System
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
PES	Payment for Environmental Services
PROFIEET	Promoting Farmer Innovation and Experiences in Ethiopia
PSNP	Productive Safety Net Program
PWDP	Participatory Watershed Development Planning
R&D	Research and Development
RELMA	Regional Land Management Unit (at ICRAF)
REST	Relief Society of Tigray
RWH	Rain Water Harvesting
RWM	Rain Water Management
RWS	Rain Water System
SAP	Subsidiary Action Program
SARDP	SIDA-Amhara Rural Development Program
SCRP	Soil Conservation Research Program
SDPRP	Sustainable Development and Poverty Reduction Program
SIDA	Swedish International Development Agency
SIP	Strategic Investment Program for Sustainable Land Management in Sub-Saharan Africa
SLM	Sustainable Land Management
SLWM	Sustainable Land and Water Management
SLUF	Sustainable Land Use Forum (Ethiopia)
SNNPR	Southern Nations Nationalities and Peoples Region
SNV	Stichting Nederlandse Vrijwilligers (Foundation of Netherlands Volunteers)
SSA	Sub-Saharan Africa
SSI	Small scale irrigation
SUN	Sustainable Use of Natural Resources for Food Security Project
SVP	Shared Vision program
SWC	Soil and Water Conservation
SWCD	Soil and Water Conservation Department
TBIWRDP	Tana Beles Integrated Water Resources Development Project
TDA	Tigray Development Association
TLU	Tropical Livestock Unit
TOR	Terms of Reference
TTT	Team Today and Tomorrow
UN	United Nations
UNDP	United Nations Development Program
USAID	United States Agency for International Development
VAM	Vulnerability Analysis and Mapping
WFP	World Food program
WH	Water harvesting
WHIST	Water Harvesting and Institutional Strengthening in Tigray
WOCAT	World Overview of Conservation Approaches and Technologies
WP	Water Productivity
WSDP	Water Sector Development Program
WUA	Water User Association

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On 28-30 September 2010 we had the privilege of participating in workshops for planning and launching the CPWF Nile Basin Development Challenge Program. The findings of this study were presented and discussed in some detail, and we are grateful to workshop participants for their positive responses and useful comments. Don Peden provided useful suggestions for improving the section on livestock water productivity. Seleshi Bekele made useful suggestions for improving the paper; and Tilahun Amede, CPWF basin coordinator, provided detailed comments and suggestions on the earlier draft. We have tried to respond to all of these valuable comments; they have certainly helped clarify and improve the study.

Working on this project has broadened our own knowledge and understanding of a complex problem and for this opportunity we are grateful. We hope this report will be useful to the CPWF researchers in planning and implementing the next phase of research, as well as to others interested in rainwater management experiences in the Ethiopian Highlands. We also believe that our findings and recommendations on current policy and implementation programs may be of use. The new Five Year Growth and Transformation Plan for 2010-2015 was announced only after this work was done; but the recommendations seem no less valid than before.

We are solely responsible for any errors of fact or interpretation, or omissions of key knowledge areas.

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Summary of Main Conclusions and Recommendations

Introduction

This study synthesizes existing knowledge, lessons, and gaps in knowledge from Ethiopia's experiences with rainwater management systems for production – in other words, sustainable land and water management interventions. "Rainwater management" (RWM) is defined broadly and includes soil and water conservation, sustainable land management, rainwater harvesting, conservation farming and micro irrigation – management of water for crops, livestock, agro-forestry and fish productivity. The study is based on a review of nearly 400 sources, including policy papers, project documents, and research studies. We have approached the subject from a broadly historical perspective, tracing changes in policies and strategies from the 1970s to the present as policy makers, implementation agencies and development partners learned from experience. We have also traced the results and outcomes of associated research programs and identified knowledge gaps. Based on this detailed review we have made recommendations regarding policies and implementation strategies, and for research. The study was commissioned by the Challenge Program on Water and Food (CPWF) whose second phase of work in the Nile Basin will address a critical "Basin Development Challenge:" ***"improving rural livelihoods and their resilience through a landscape approach to rainwater management."*** We have therefore focused primarily on experiences in the Ethiopian Highlands with special reference to the Abay (Blue Nile) River Basin.

Our conceptual framework has been based on two broad concepts. The first is what the CPWF calls a "landscape approach to rainwater management," which is complementary to the concept of "integrated watershed management" (IWM). Both share a systematic integrated systems paradigm; but IWM emphasizes hydrological boundaries while the landscape perspective considers broad social, economic and institutional networks that may cross-cut hydrological boundaries. In this framework, watersheds are conceived as socio-agro-ecological systems; the objective of the research is therefore not necessarily to find ways to maximize the output of one element of the system (say, crop production), but to optimize the range of services provided by the watershed resource system in a manner that is sustainable and beneficial to the broad range of stakeholders. The second is what we have called an "innovation system" paradigm; the CPWF uses the term "learning platform" and others use terms like "value chain platforms." The underlying idea is that to optimize the relevance and uptake of research results, research must be carried out from the beginning as a partnership of multiple stakeholders learning together. Research cannot be left to the researchers alone, who then transfer their results to extension agents for further dissemination. This is especially the case when the research is focused on agro-ecological systems such as watersheds.

The study presents detailed observations, conclusions and recommendations for two purposes: improving existing policies and programs; and providing guidance to both the CPWF research program and more broadly researchers working on rainwater management systems in Ethiopia. These are presented in volume 1. Volume 2 contains a detailed annotated list of all the references consulted as well as data tables on policies, implementation and research programs, lessons from selected specific interventions, and inventories of organizations working on rainwater management in Ethiopia as well as potential future partners. The study was completed before the new 2010-2015 "Five Year Growth and Transformation Plan" was announced.

Conclusions and recommendations for implementation programs

Observations

Expansion of cultivated area, reducing natural forests and grasslands, and intensifying grazing in smaller and smaller areas to accommodate a growing population has been underway in the Ethiopian Highlands for centuries. While there has been little productivity-enhancing technological innovation until recently, farmers did develop and use indigenous practices to minimize land degradation and maintain soil fertility. But by the mid-20th century, with increased population growth rates in a context of a political system centered on an emperor and a tiny elite controlling most of the land and other resources, the entire agricultural, political, economic and social system was losing its resilience. Periodic famines have occurred throughout Ethiopia's history, but extremely severe droughts and crop failures in the mid-1970s provided an opportunity for a new military regime (the *Derg*) to replace the old feudal system. It implemented radical reforms, especially nationalizing all land and setting up a system for periodic redistribution of plots among families, reorganizing rural institutions, and expanding support for agricultural development, emphasizing state-owned commercial farms and the collectivization of production systems among smallholders. However, there was little improvement in productivity and famines continued to weaken the state, which lost considerable international support as well as the support of significant groups within the country. In the early 1990s it was overthrown and replaced by a new government. The current government has retained some of the previous policies, for example land tenure reforms and the emphasis on agricultural development, but has made major changes in their implementation. It also created a new decentralized federal government system under a new constitution, and has attracted high levels of support from the international community. The government has worked hard to develop new development policies, based on agricultural development as the main driver for achieving poverty reduction and economic growth. It is investing heavily in rural and urban infrastructure, and provision of basic educational and health services. Despite impressive achievements, and because of the extremely low starting point, Ethiopia remains one of the poorest countries in the world, and over 12 million people – in some years more – remain food insecure. Its agricultural productivity remains low, dominated in the Highlands where about 90% of the population lives, by low input-low output rainfed mixed crop-livestock production. Its lowland pastoral and agro-pastoral areas also remain vulnerable to drought.

The crises of the 1970s and 1980s brought to the world's attention the rapid rate of land degradation underway in the Ethiopian Highlands. This degradation, coupled with nationalization of rural land and all privately owned commercial agricultural enterprises, and the infamous policy of a forced collectivized production system and "villageization" came to be perceived as the root cause of low agricultural productivity and an existential threat to the future of Ethiopia. In the early to mid-1980s, two research programs were initiated to quantify the land degradation problem, understand its underlying dynamics, and identify measures to reverse it. Simultaneously, beginning in the early 1970s, food aid and relief efforts became directly linked to efforts to reverse land degradation through various food for work (FfW) programs. This linkage has continued to date: FfW and recently cash-for-work programs have been used as a means to provide much-needed food aid to rural people, while also requiring them to earn the food through rural public works. These included building roads and public buildings; but a major component has been the construction of soil and

water conservation structures intended to prevent or reverse erosion processes. More recent programs have widened this emphasis to include rainwater harvesting ponds, shallow wells, and diversion structures, biological as well as physical land management structures, and most recently, promotion of income-generating projects.

Lessons learned from policy implementation programs and key recommendations

Historically, the Ethiopian political system and culture has been authoritarian and male-dominated. It is therefore no surprise that the early sustainable land management (SLM) programs were driven from the top and often used coercion in various forms to meet quotas established at higher levels. Through these early programs, rural people created thousands of kilometers of stone and soil bunds, in some cases through "voluntary" community labor, and in others through FfW programs. While the food aid undoubtedly saved millions from starvation, the value of much of this SLM investment is questionable: when the *Derg* was replaced by the current government, a large percentage of these structures were deliberately destroyed. There is considerable evidence that soil and water conservation (SWC) structures promoted by government are even today often not perceived positively by farmers, usually for good reasons. There are many reported cases of inappropriate technologies being promoted, and construction of structures that are then not used. For some years under the new government, the top-down food aid-driven programs continued, perhaps with less overt coercion, but driven to a large degree by food aid. By this time, it is likely that some of the results of the early research programs, especially the Soil Conservation Research Project (SCRP) were influencing the specific technologies promoted (for example *fanya juu*), though they provided no guidance on implementation strategies. On the other hand, although on a limited scale, there is an excellent example of community-owned and managed SLM practiced by the Konso people in Southern Nations Nationalities and Peoples Region. The Konso people have used traditional SWC conservation practices for generations, without interventions from the government, FfW, or NGOs. These have enabled the community to maintain the productivity of their agricultural systems on a sustainable basis.

Evaluations of donor-supported government programs, combined with several bilaterally funded integrated rural development programs and the experiences of NGOs, all began to demonstrate the need for a new approach to implementation. The lead program in this process has been MERET ("Managing Environmental Resources to Enable Transitions"), a three-decade collaboration of the World Food Program and the Ministry of Agriculture and Rural Development (though the name "MERET" was more recently adopted). This program, complemented by others, began moving from a top-down implementation strategy to one that is more community-driven. It initiated and refined based on experience a "Local Level Participatory Planning Approach" (LLPPA) that enhanced the voice of community members in planning and implementing SLM programs. Based on this approach and other material, the Ministry of Agriculture and Rural Development produced the "Community Based Participatory Watershed Development" (CBPWD) guidelines in 2005. These have been widely disseminated and are now used as training and implementation guidelines in nearly all SLM projects. CBPWD is the basic guide for a new large-scale 15-year SLM program being implemented by government and its development partners. More recently, MERET and other programs have broadened to include biological SWC measures, forestry and agro forestry, area enclosures to encourage regeneration of vegetation, and income-generating activities.

These changes demonstrate a commendable capacity for learning from experiences and changing approaches based on the lessons of the past. Nevertheless, many challenges remain. Although the guidelines and training programs emphasize "participation" of communities, it will take many years to change the dominant culture of government and indeed communities from an authoritarian to a democratic mindset. Establishing quotas from the top continues to be policy, and continues therefore to drive local officials' behavior as their performance is evaluated based on this simple-to-use monitoring tool. In some instances using FfW as motivation for SWC works may also be leading to a dependency mentality on the part of farmers. Capacity limitations both in terms of number of trained staff and the quality of the training, combined with logistical and other resource limitations, continue to have impacts. Rapid turnover of staff along with frequent institutional re-organizations are also common complaints.

The new guidelines and current approach to promoting SLM is far more participatory and community-driven than in the past, with an emphasis on local consultation and planning on a watershed basis. Nevertheless, the programs remain based on the concept of promoting a limited number of "best practice" packages. There is insufficient recognition of the potential value of building on and improving farmers' knowledge and indigenous practices. *We recommend the government further modify its implementation procedures to encourage partnerships with local communities, engaging them in a creative innovation process of solving their own problems by drawing on and integrating a wide menu of indigenous and introduced technologies.*

In this context, the performance evaluation problem could perhaps be solved by implementing performance assessments based on clients' feedback: if a watershed program is truly demand-driven, the community will make use of the expertise of the DAs and can assess the usefulness of the assistance received. This would also empower the communities, shifting the balance of power in their favor, and increase the likelihood of longer term sustainability. *We recommend pilot testing client-based ways of creating incentives to make extension staff more responsive to their clients*.

Another limitation in some current SLM programs is they have not completed the transition from reducing land degradation as an end in itself to improving water and land management in order to increase and sustain productivity. It is true that MERET has widened its scope to include income-generation, and that rainwater harvesting technologies such as ponds and wells are now promoted by regional governments as well. But it is not clear to what extent these initiatives are integrated into the new SLM Program financed by the World Bank, GEF, IFAD and others. A major finding from both research and practical experience is that people are so constrained in terms of meeting basic short term consumption requirements that they cannot wait for benefits from SWC that at best accrue only in the future; they need immediate benefits. This would suggest that programs should focus even much more on providing the means for people to raise their productivity in the short run, while encouraging longer term investments that are complementary and phased in over time. Another problem with the focus on reversing land degradation as a goal in itself is that it fails to address the need to improve productivity of water as a complementary – perhaps even preceding – goal. Put differently, rather than seeking to reverse land degradation, which is a negative goal, *we recommend fully adopting a positive goal of assisting farmers to sustainably increase productivity as the driving force*.

The Ethiopian government has adopted comprehensive and well-thought out policies to promote agricultural and rural development, water resources development and management, environmental conservation, and poverty reduction among others. We noted, however, that there is no specific policy with regard to the management of rainwater – specifically so-called "green water." The water resources policy focuses entirely on developing surface and ground water – "blue water." The new SLM program retains a goal of reversing land degradation, with insufficient attention to the goal of enhancing the productivity of rain water. The program is based on an integrated watershed management paradigm. A missing element is a set of clear incentives to encourage investing over the long term to improve and sustain the productivity of rainwater. *We recommend that the government develop a specific "green water" policy integrating land and water management based on an integrated agro-ecological watershed paradigm, integrated with the water resources, agricultural and rural development and environmental sustainability policies, and providing positive incentives for long-term investments.* Managing water for productivity and ecosystem functions should start from rainfall and examine the entire continuum, from field level to large-scale infrastructure options.

In this context the lack of research on water management technologies and practices combined with the minimal integration of water management, land management, and management of livestock and agro forestry, and non-availability of low-cost equipment such as treadle and manual pumps, drip irrigation kits and small power pumps, are major impediments to progress. We make a recommendation for research below. Its results would support developing a specific policy and institutional framework for encouraging a market-based agricultural water management industry policy.

Most observers recognize the need to strengthen the partnerships among farmers, extension staff, researchers, and indeed other stakeholders. Many RWM programs have had mixed outcomes, not because the technologies were not useful but because of implementation weaknesses. Several evaluations have noted the lack of good advice to farmers on how to make productive use of water. It is also clear that implementation programs have not been sufficiently linked to research programs: there needs to be a synergy where research priorities are identified by the clients (farmers, implementing agencies, policymakers), research is carried out in partnerships among stakeholders, and results of research are absorbed quickly into the implementation process. Researchers have also identified a host of policy and institutional issues that affect adoption and continued use of SLM and RWM. A long-term strategy is needed that offers communities a menu of practices and technologies, capacitates them to make informed choices and develop their own watershed management plans, supports them to implement these plans and adapt their practices over time as they learn from experience, and encourages a continuous process of innovation and sharing of new ideas. *In this context, we recommend a stronger focus on building community-based institutions to enable water and watershed users to take responsibility for managing their resources.* Even a decentralized government cannot effectively manage small watersheds; their role should be to support and facilitate community management.

Finally, the national research system has for quite a long period of time been dominated by crop breeding and the identification of improved or new varieties as well as soils research. As a result, support to natural resources research, i.e., land and water management and RWM, has been extremely limited. Natural resources management research capacity needs to be strengthened and

modernized, including strong partnerships with clients. In addition, until very recently, the government has been concentrating on the reversal of land degradation problems in drought affected and marginal areas while pushing use of improved seeds and fertilizers to boost production in some of the high potential areas of the country, with little regard for sustainable management and use of natural resources in these areas. This neglect has also contributed to the exacerbation of the problem and the continued shortfalls in overall food security. The new SLM Program shifts focus to improving land and water management in high potential areas as well, a welcome change. *We recommend major long term investments to strengthen Ethiopian natural resources management research capacity based on an innovation systems paradigm.* The latter is discussed further in the next section.

Conclusions and recommendations for research programs

Gaps in knowledge

Compared to most countries in Africa, Ethiopia has a long history of large-scale research programs on sustainable land management. Three decades of research in Ethiopia have produced a large body of knowledge on land degradation processes and impacts, the performance of various land management and soil water conservation technologies, targeting of SWC interventions, the effectiveness of various implementation strategies, and the impacts of policies on incentives and productivity. However, the results reported from this research are often contradictory, with, for example, some researchers reporting high returns from SWC interventions, and others reporting minimal or even negative returns. There has been very little systematic comparative research on the diverse SWC technologies, their performance, the conditions for which specific technologies are most appropriate, and the accompanying crop, land and water management practices needed to enhance their productivity. If farmers continue to plow the land six times for teff, how does this affect the return on investment in terraces, for example? There is insufficient research on the actual costs and benefits of maintaining various types of SWC technologies though these may be important determinants of farmers' willingness to sustain them. (Most of that research raises questions about the long-term returns to farmers; but the returns in terms of downstream benefits are not adequately captured in these studies.) Nor has there been research examining the comparative performance of indigenous and introduced technologies, the extent of private investment and spontaneous outscaling, and what factors affect these. Finally, much research has focused on erosion control but far less has tried to identify how farmers can better manage soil fertility and rainwater in a way that is both affordable and productive.

Water management practices and technologies, the various ways to improve the productivity of water used by crops, livestock and agro forests, and the outcomes and social and economic impacts of these technologies are not well-researched in Ethiopia. Water management has been largely neglected by both the international and national research organizations. For example, we found no research studies examining the performance of and potential market for low-cost small-scale individualized water management technologies such as treadle pumps, drip and spray irrigation, and small power pumps. Similarly, while there is some research on the uptake, use and economic returns of RWM ponds and shallow wells (much of it reporting contradictory results), we found no research examining their water productivity and ways to improve their sustainability and productivity. Another important research gap relates to the interactions and synergies among diverse RWM technologies and practices: much of the research examines the performance of a

single technology in multiple sites rather than the outcomes of a suite of practices implemented in an integrated fashion on a watershed. What would be the outcome of implementing with interested farmers an integrated multi-pronged program that combined physical and biological terraces, reduced tillage agriculture, agro forestry, *ex situ* RWH and shallow wells, regulated use of common grazing lands, and introduction of small livestock? And how can the potential for shallow groundwater use in small watersheds be identified cost-effectively, and how can its use be managed to achieve sustainable, equitable and productive outcomes?

Research on improving livestock water productivity is also in its infancy: while there has been useful conceptual work and some assessments of productivity under different conditions (largely with BMZ and CPWF support), to date there has not been any action research testing livestock management options, or the relative advantages of small versus large livestock, from a water productivity perspective. Similarly, while agro forestry has been identified as an important pathway to improved and sustainable water productivity, there is little research aimed at demonstrating how to achieve this goal. More broadly, there is very little research on how to achieve improved water productivity and (aside from some work on irrigation investments) on what would be the implications of achieving higher WP in terms of sustainability, poverty and food security impacts, and economic growth. Research on the impacts of upstream RWM interventions on downstream stakeholders and resources is also in its infancy.

There is also a need for more nuanced in-depth local level case studies on local cultural, social and institutional dynamics from a socio-technical perspective. Although policy and implementation rhetoric is participatory and gender-sensitive, the actual local political and social processes and their impact on who benefits and who does not from government programs are likely to be at variance to the rhetoric; there is only a little research on this in Ethiopia, though it has been documented frequently elsewhere. For example, more often than not, well-intentioned "participatory" programs tend to exclude the poorest people, especially women, from both decision-making and sharing of benefits. Related to this, researchers have not examined actually program implementation processes and outcomes at local levels. We do not know enough about what actually transpires as the Productive Safety Net Program, MERET and other programs are implemented, and therefore we are not able to advise effectively on strategies to improve targeting and effectiveness of such programs. A broader point, related to the discussion of implementation experiences, is there have never been sufficiently strong linkages between SLM-RWM research and implementation programs in Ethiopia. Implementation programs have rarely included an applied research program integrated into the implementation process.

In view of the huge investments made in SLM and RWM by various programs over the past few decades and planned for the future, it is a surprise that there has never been a systematic comparative evaluation and assessment of these interventions, their outcomes and achievements, and lessons learned to guide the future. Therefore, new programs often repeat the same mistakes as past programs, in terms of implementation strategy, promotion of inappropriate technologies, and insufficient attention to local level institutional capacity-building. Such an evaluation must take a watershed and landscape perspective, and examine for example downstream impacts of upstream conservation interventions and the distribution of benefits and costs.

Multidisciplinary participatory action research on RWM is incredibly rare in Ethiopia; to our knowledge the major exception was the African Highlands Initiative, but this was focused on how to promote collective action and on land not water management. Other programs such as AMAREW, the GTZ integrated food security project, and perhaps ILRI's Integrated Productivity and Market Support Program are partial exceptions. It is clear from this review that there is a need for scaling up RWM research, governed by a new paradigm.

Elements of a new paradigm RWM research program

The CPWF recognizes that single-factor interventions, whether they are SWC structures, rainwater harvesting practices, or improved livestock management, may not by themselves lead to optimum outcomes. Therefore it has designed its next phase as an integrated watershed or "landscape" program. It includes four action research projects focused respectively on: 1) integrated rainwater management strategies integrating technologies, institutions and policies; 2) targeting and scaling out; 3) assessing and anticipating consequences and outcomes of innovation, for example downstream externalities; and 4) coordination and multi-stakeholder platforms aimed at ensuring synergies among the CPWF projects, using outcome logic models to provide strategic guidance on achieving impacts, fostering change through mapping and engaging with RWM actors, and promoting communication and sharing among RWM researchers, policymakers and implementers. The latter project also promotes capacity building and gender mainstreaming. These projects constitute the potential elements of a participatory innovation system research and development program, but they require some important adjustments. These are discussed under five headings.

1. Innovation system including multiple stakeholders

The CPWF proposes to work with other researchers as well as policymakers, development actors, and of course farmers. Working with and through national and regional research institutions and universities is critical and is part of the plan. But we suggest the CPWF NBDC projects should cast their net wider, and include, at multiple levels, other actors. At local level, small agro-business people, traders, health specialists, and religious leaders could be included, in addition to those already included (e.g., NGOs, government officials); some will play passive advisory roles; others may wish to be actively involved. Examples include identifying options for research, pathways for scaling up and out, and implementing research activities. At regional and national levels, CPWF should actively involve key agri-business people (on both the agricultural services and input supply side and the agricultural produce demand side), policymakers, researchers, middle-level officials (representing the future policymakers), development partners, consulting firms, and NGOs. This "involvement" should go beyond periodic "consultation" through occasional workshops and include invitations to participate actively in the entire research process. It is especially important to engage with the leaders of RWM-SLM investment programs: these are likely to be major sources of suggestions on knowledge gaps, and the major pathway for uptake of new research findings. Such a wide-ranging intensive and active engagement should enhance the potential innovativeness of the research program, increase the likelihood of buy-in and longer term support, and result in beneficial spin-offs, for example more private sector initiatives in scaling out new technologies. It may also lead to higher levels of demand for both applied research services and the products of the research.

2. Farmer-driven participatory innovation development

It is often claimed, incorrectly, that Ethiopian agriculture has failed to innovate spontaneously for higher productivity, reflecting an assumed conservatism and reluctance to change on the part of

Ethiopian farmers. This is not the case, as experiences with promoting modern maize and wheat production, has shown: when the benefits are clear with good market access, Ethiopian farmers respond. There is also, however, the question of farmers' own innovativeness. In recent years there have been a number of small-scale programs, such as Prolinnova, to enhance and strengthen local-level innovation processes and harness the dynamics of local knowledge by identifying local innovation processes and supporting farmer creativity. Such participatory innovation development goes far beyond the "normal" participatory action research where farmers agree to try something on their fields proposed by researchers; rather it engages farmers fully as partners, co-equal sources of ideas about innovations as well as partners in implementing and evaluating the results and then communicating them. Such a process can be used to develop and test institutional as well as technical and management innovations. But it requires considerable personal skill to establish this kind of working relationship with farmers, and of course farmers living on the edge of subsistence do not have much time or other resources to devote to research. It will require identifying those farmers who already have a passion for trying new things and working with them to enhance their effectiveness. We suggest it may be valuable to engage with and seek to influence existing farmer participatory innovation development programs as a way to scale out testing of innovations.

3. *Integrated synergistic multiple interventions*

Too much past research has focused on single system components, such as technologies or institutions, rather than on watersheds as complex systems. But the complexity of agro-ecological systems is one of the main stumbling blocks to scaling out innovations to improve the effectiveness of water management. Watersheds may be conceived of as open complex adaptive systems, i.e., they are "systems" because of the interconnectedness of their elements (physical, biological, climate, humans, information, etc), such that they cannot be defined or understood solely in terms of their component parts. Therefore, their dynamics must be understood in system, not elemental, terms. This concept underlies the "landscape" approach proposed by the CPWF. We make a distinction between systemic and non-systemic interventions. Systemic interventions are those that must take account of the complexity of the system, because they will interact with other system elements in complex, often unpredictable ways, and may be transformed or rejected as part of this process. Non-systemic interventions are those that are simple enough that they have no transformative systemic interactions. Most RWM innovations are likely to be systemic. As a result, seeking to maximize returns from one element (say, crop yield in a season) may have unintended, possibly deleterious impacts on the system as a whole (for example soil nutrient depletion). On watersheds, RWM interventions in the upper watershed are likely to have important impacts in the lower portions of the watershed; the benefits of SWC may be far higher for downstream stakeholders than for those implementing them upstream; or water capture and storage interventions may deprive downstream people.

Therefore, rather than promoting short term gains in one element, it is critical to examine how to introduce innovations that will increase the capacity of the system to produce a range of outputs in a way that does not threaten its integrity or lead to inequitable sharing of benefits and costs. This creates a dilemma in the Ethiopian Highlands since the central elements of the system — human beings – face serious consumption challenges and are therefore often forced to adopt survival strategies that threaten the long-term integrity of the system. It may therefore be essential to provide additional exogenous support and incentives over the medium term to enable people to move the system to a more sustainable and productive level. An example is payment for

environmental services as there are substantial positive externalities and public goods resulting from improved upper watershed management. It may also be possible to identify a set of interventions that, in sequence, move from achieving higher short term productivity to meet immediate needs to longer term evolution of the system to enable optimizing outputs at the system level. Participatory modeling and GIS are tools that can assist in identifying opportunities, and enable people to visualize trade-offs and potential synergies among interventions.

4. Examination of local social and economic dynamics

A critical subsystem of watershed-based agro-ecological systems is the human socio-economic system. The productivity of water and other resources and the distribution of the costs and benefits of exploiting them are ultimately a function of the effectiveness of policies and institutions. And in most watersheds, collective management of resources is a necessity for long term sustainable production. However, conceptualizing this system is not straightforward and social scientists have highly contentious debates on this. A relatively straightforward approach is to adopt an institutional economics perspective. Proponents of this approach have attempted to identify basic rules and "design principles" that are seen as universal and provide a basis for designing, "crafting," and even "engineering" institutions. The notion that one can use universal design principles to create institutions, rather like designing a building, is attractive. Unfortunately it is misleading and impractical because, among other reasons, it oversimplifies human motivations. An alternative approach can be built around a more contextualized concept of institutions and organizations that recognizes they are inherently political, socially embedded, complex and unbounded, with actors playing potentially creative roles but driven by a complex mixture of conscious and unconscious goals, not all of them consistent with the single-minded "rational" principles of institutional economics. This perspective is summarized under the term "institutional *bricolage*". Change agents are do-it-yourself handy men, *bricoleurs* and not social engineers. *Bricoleurs* improvise and borrow bits and pieces from multiple sources to create innovations, while engineers solve problems by applying scientific principles to design solutions. Social and institutional change occurs through the same creative non-linear process, driven by creative human agents with complex goals. Rather than attempting to graft a new kind of institution into an existing socio-economic-technical system, encouraging *bricolage* processes has the advantage of building on indigenous institutions, but modifying and adapting them, grafting new ideas (for example women representatives) into older ways of doing things.

The lack of research on local social, political, economic and cultural dynamics and their integration into management and adaptation of technologies is a serious gap in knowledge that limits our ability to effectively promote RWM innovations. Local power relations largely determine what interventions may be adopted, who benefits, and who pays the costs. Those who are poorest, with the least power and influence for example landless people – the people most in need of support – may or may not benefit, but they surely will have no voice in the decision-making. The powerlessness of women is worsened by cultural norms limiting their roles in public life and restricting their productive activities. Some innovations may make their situation worse, for example by adding to their workload, even if they lead to higher overall (system) productivity. We therefore need more in-depth studies of local social, gender and institutional dynamics as a basis for identifying and promoting innovations that are productive and equitable. An effective integrated landscape approach to watershed management must include attention to *all* stakeholders, not only those farming their own holdings.

5. *Testing and assessing institutional and implementation innovations*

A major finding of the study is that the absence of strong, effective and appropriate policy and institutional incentives is a major deterrent to adoption of better water and land management practices. Economists have documented the lack of credit facilities to finance RWM improvements, inadequate access to functioning input and output markets, and insufficient access to information and knowledge. This suggests that far more attention needs to be paid to improving the policy framework and institutional capacity for implementation. Complementary to this, we also suggest that there needs to be more testing and evaluation of potential institutional innovations, adapted to the Ethiopian Highland context. Examples that have been suggested by others working in Ethiopia include payment for environmental services, providing weather index and indemnity insurance, and using "interlinked contracts" to create positive incentives for investing in water and land management. For those farmers selling produce into the markets, inventory credit systems such as those being tested in West Africa could be considered.

In addition to these, far more work is needed in partnership with farmers to identify ways to strengthen collective management of common property resources and make them more inclusive as well as more effective in management watersheds. This work should build on both indigenous arrangements and promising efforts to introduce new institutional arrangements like Community Watershed Management Organizations. An especially problematic area is management of protected common grazing and woodlot areas: indigenous institutions could be strengthened in some cases, while in others creation of new institutional arrangements may need to be supported. With the emergence of water as the key entry point in watersheds, there is also a need to explore new institutional arrangements for watershed management, through which all stakeholders from the top to the bottom of watersheds – including watershed resource users and local government representatives – can work out how to share the benefits and costs of introducing innovations aimed at sustaining and improving the productivity of land and water. We stress here, based on global experiences, that government cannot manage small and medium-sized watersheds effectively. It can however play a critical role in facilitating, encouraging and supporting watershed user-based management institutions.

Finally, because questions have been raised about the impacts of Food for Work (FfW) on long term incentives, another promising area is to identify either alternative implementation strategies that could be used in areas where food aid is less critical, or alternative ways to provide FfW. In high-potential areas FfW is not necessary in any case, and to the extent possible even in drought-prone areas, FfW and integrated watershed management should be delinked. Examples include linking the latter to the government's land certification program, and tying payments to the community to completion of specific targets agreed by the community and implementing agency, provision of community benefits rather than private rewards, and prizes for community innovations and watershed systemic improvements. These are simply illustrative examples; the point is not to impose new institutional arrangements; rather, it is to engage with watershed users to catalyze and support creative institutional *bricolage* processes.

Recommended research on under-studied topics

The new policy recently announced by government considers water as a key entry point to raise agricultural productivity ("water-centered agricultural growth"). This focus is very welcome, but needs effective research support. In this context, the potential list of topics requiring more research

is endless; therefore we do not try to propose a comprehensive list. We recommend the following topics be considered for research investments by the CPWF, SLM Program, universities, Ethiopian Institute for Agricultural Research, and the regional agricultural research institutions.

1. Basic in-depth case study research on the evolution and trends characterizing small and larger watersheds from an integrated agro-ecological perspective, complementing existing M.Sc. and Ph.D. studies identified in this study. This work should be complemented by more long term interdisciplinary research on upstream-downstream processes and interactions on both small and large watersheds, quantifying downstream impacts of changes in upper watersheds, and building on the recently completed CPWF project. Within this context, test and adapt models that can be used for identifying outcomes of potential interventions as planning and monitoring tools. GIS and remote sensing are becoming increasingly accessible and affordable but remain under-used; for example a study of irrigation scheme productivity in the Nile Basin supported by EWUAP demonstrated how much can be learned through using such tools to assess evapotranspiration.

2. River basins and watersheds at various levels are emerging as key planning and implementation units. Studies of alternative institutional arrangements and processes for integrated management of river basin resources are needed, especially given the complexities and challenges of the Nile Basin. Such arrangements need to be nested, i.e., institutional arrangements at the level of small watersheds nested into larger frameworks; they should provide mechanisms to reflect and where feasible give priority to local needs as long as they do not reduce benefits elsewhere. Such studies should identify the optimum roles of *woreda*, *kebele* and community level institutions and adjustments or innovations that may be needed. Alternatives to the normal international models of river basin organizations are needed, for example developing from indigenous roots.

3. In view of the growing interest in using water management as a development entry point, it would be timely to re-examine the current institutional arrangements for land and water development and management; for example the ministries in charge of water resources and agriculture do not have a defined mechanism for collaboration. Therefore a study should be proposed and if accepted implemented in collaboration with the government to address two related issues: the institutional arrangements for integrated water and land resources management; and adjustments needed in the existing water and land policies to ensure effective implementation. As noted above, this should include development of a rainwater management policy integrated with water and other policies.

4. In the previous subsection we noted there has never been a systematic in-depth authoritative comparative study of the implementation strategies, effectiveness, impacts, outcomes, and lessons learned from the large number of SLM and RWM programs implemented in the last two decades. We recommend that the government commission such a study. Its findings could be extremely useful in designing future RWM programs.

5. Detailed definitive and authoritative comparative assessments are also needed of poverty outcomes, returns on investments, and sustainability of alternative RWM technologies and practices, and the interactions among them in watersheds. This study could also assess the effectiveness of targeting, for example of women and poorer households.

6. As noted previously, there is currently no systematic research on the impacts, outcomes and effectiveness of water lifting and water application technologies (i.e., treadle and power pumps, low-cost drip and sprinkler irrigation kits) and their potential future market.

7. We found very little information on the effectiveness of NGO programs in SLM and RWM. While the general assumption is they are relatively effective, there is no evidence this is the case. A part of such a study should also explore how to create better synergies and sharing of lessons between official and NGO programs.

8. Finally, there have been and continue to be many international and Ethiopian research organizations working on topics related to RWM. However, there has been no research on how effective they are in terms of impacts on technologies and practices adopted by farmers, policies, and implementation strategies. We do not have systematic information on how effective is collaboration between international, national and Regional research institutions and universities, or guidelines on what could be done to improve their effectiveness in terms of quality of outputs and value of impacts. Research on research may have very high payoffs in terms of understanding what kinds of research programs are most effective and have the highest returns.

Conclusion

We believe that Ethiopia and its development partners have invested more in improving water and land management (RWM) than any other country in Africa. It probably ranks third, after China and India – far larger countries. This demonstrates the vital importance and priority given to rainwater management. We have shown how, over the past three decades, Ethiopia has adapted and improved its policies and implementation strategies based on lessons learned and results of research. It has adopted participatory approaches, a livelihood focus, and an integrated watershed management paradigm. The combination of the launch of new programs such as the SLM Program, an increasing awareness by the government of the need to use water more productively (captured in the term, “water-centered growth”), and the launch of the CPWF Nile Basin Development Challenge initiative offer significant opportunities to create a new paradigm for sustainable land and water management. Our most important recommendation is that Ethiopia should now take the next step and focus on supporting community-based watershed management institutions. To be successful, there is a need for researchers, especially the CPWF program, to work with communities to test and promote institutional and technological innovations on watersheds. The government needs to further strengthen policy support for sustainable demand-driven research-based rainwater management programs. By doing so, we believe Ethiopia will achieve its ambitious food security and agricultural growth goals.

1. Introduction

1.1 The Challenge Program on Water and Food (CPWF)

The Challenge Program on Water and Food (CPWF) is a multi-partner research for development initiative of the Consultative Group on International Agricultural Research (CGIAR). It was conceived as a reform program, to strengthen the CGIAR's capacity for interdisciplinary research aimed at poverty reduction through better management of water for sustainable agriculture. This is to be achieved through creating new and broader partnerships beyond the centers supported by the CGIAR, and promoting innovative interdisciplinary science. The CPWF has recently completed phase 1 (2004-2008) and initiated phase 2 (2009-2013). The overall objective of the CPWF is to "*increase water productivity and resilience of social and ecological systems.*"[1] While phase 1 worked on nine river basins around the world, and supported a large number of essentially separate research projects, phase 2 is focusing its work on six transnational river basins. These basins are in Asia (Ganges, Mekong), Latin America (seven small basins in the Andes) and Africa (Limpopo, Nile, Volta). In each basin, a "Basin Development Challenge" (BDC) has been identified through a process of reviewing outcomes of previous research and stakeholder consultation. Based on the BDCs, approximately five project areas have been identified for each basin, and specific institutions invited to submit proposals. As of mid-2010, most of the proposals have been submitted and reviewed; and in the case of the Nile River Basin, the projects have been approved and are being initiated.

In all large complex river basins, there are many issues and challenges to be addressed. The CPWF's comparative advantage is in the area of "science for development impact at the intersection of poverty, water and food." It therefore focuses on this intersection and emphasizes integrated and participatory research and working through strong partnerships for research and uptake of outputs. It uses a variety of tools, including "impact pathway analysis" as means to maximize its potential for having a real impact on water productivity and food security. In the Nile Basin, the CPWF has identified the need to raise the very low agricultural water productivity of the basin as critical to achieving agricultural growth and poverty reduction while reversing the water and land degradation processes currently threatening the livelihoods of millions of people both in Ethiopia and downstream. The CPWF is focusing most of its resources on the Ethiopian highland portion of the Blue Nile. This is justified because it is the source of most of the water flowing into Sudan and Egypt; it exhibits a combination of relatively high numbers of people, high population density, and extreme poverty and rapid water and land degradation that are threatening livelihoods and development potential in both the upstream and downstream portions of the basin. It is also justified because of the high level of receptivity of Ethiopia to research-based policy advice, the strong commitment of the government to achieve poverty reduction through agricultural growth that is based on improving water and land management, and strong support of its development partners. In sum, focusing on the Ethiopian Blue Nile provides an opportunity for the CPWF and its partners to demonstrate the potential benefits of increasing 'the productivity of water for food and livelihoods, in a manner that is environmentally sustainable, socially acceptable, and alleviates poverty for disadvantaged groups.'

[1] See Director's note at http://www.waterandfood.org/news-and-events/directors-notes.html#c1672. This is a modification of the previous overall objective, *"to increase the productivity of water for food and livelihoods, in a manner that is environmentally sustainable, socially acceptable, and alleviates poverty for disadvantaged groups"* (CPWF 2009).

The Nile Basin Development Challenge (BDC) is specifically "***to improve rural livelihoods and their resilience through a landscape approach to rainwater management***." The term "landscape" draws attention to the critical importance of taking an integrated approach (including land, water, crops, livestock, crops, etc.) at a watershed level. "Rainwater management" (RWM) draws attention to the need to capture, store and use rainfall in a way that is productive and avoids environmental degradation. Rain may be captured by a variety of rainwater harvesting techniques either *in situ* or *ex situ*; and used for multiple purposes, both productive and domestic. Successful implementation will lead to higher productivity of water (more value produced per unit of water consumed) while minimizing and even reversing land and water degradation. The Nile BDC is being implemented through five separate but coordinated and integrated projects[2]:

Project N1: Learning from the Past (this report)

> The purpose of is to develop a history and synthesis of the experiences of programs and projects on rainwater management (RWM) in Ethiopia. Project N1 will find out which RWM innovations have worked when, where and why; what did not work very well, and why; and what lessons can be extracted from past experience to guide CPWF research in the Nile over the next 4-5 years. The outcome of this project – this report – should inform the work done under Projects N2-N5. This is explained further below.

Project N2: On integrated rainwater management strategies – technologies, institutions and policies (IWMI is the lead institution, with ILRI, ODI and ICRAF)

> Integrated rainwater management strategies combine technologies, policies and institutions. Work in this project will aim to integrate land and water management, crop component technology, crop management, crop-livestock systems, pastoral systems and agro forestry systems so as to raise productivity and incomes and enhance resilience, while slowing land degradation and reducing downstream siltation. This project will also examine the extent to which policy change and institutional strengthening and reform can combine with new technologies to spur widespread innovation. It will look into micro-credit, cooperative societies, land tenure, collective action in communities, and the various roles of formal and informal institutions, as part of integrated strategies to improve rainwater management.

Project N3: On targeting and scaling out (ILRI and IWMI)

> This project is about matching technologies (or whole strategies) with environments. It has been shown that "blanket" rainwater management strategies are often inappropriate. One size does not fit all. Strategies for upper slopes are likely to be different than those for lower slopes. The suitability of technologies may be influenced by altitude, rainfall patterns, landscape position, soil type, access to input and product markets, crop-livestock interactions, the extent of community integration, the attitudes of local authorities, the presence of NGOs and other development organizations – and many other factors. Therefore, this project will aim to identify the conditions – biophysical and institutional – that favor the use of particular sets of practices, then scan the landscape to find out where else these conditions prevail. That is, this project will help identify the "conditionality" of

[2] These summaries are derived from the TOR for Project N1 and the proposals submitted for Projects N2-N5.

recommendations. Sometimes these conditions may be amenable to mapping, as when altitude is a determining factor. Some the conditions will be difficult or impossible to map, as when community integration is a determining factor.

Project N4: On assessing and anticipating consequences of innovation (IWMI, with ILRI and others)

This project is about showing whether Rain Water Management Systems (RMSs) are effective. It will seek to quantify the consequences of improved RMS for community livelihoods, resource productivity, land quality, and downstream water quality and siltation. It will specifically measure the downstream, cross-scale consequences of successful innovation in the Ethiopian highlands. To what extent are Sudan and Egypt affected by improved RMS in Ethiopia? The project will also develop methods to anticipate *ex ante* the likely consequences of introducing improved RMS as well as monitoring and measuring these consequences *ex post*. Finally, it will introduce methods for adaptive management, so that RMS can continue to benefit from lessons already learned.

Project N5: On coordination and multi-stakeholder platforms (ILRI jointly with IWMI)

The coordination project will ensure that synergies, lessons and interactions between the other four Nile Basin projects are fully exploited so that the whole is greater than the sum of the parts; and communication and linkages among the wider Nile BDC actors are strengthened, and successful 'significant changes' are promoted and integrated into current and emerging initiatives. To achieve this, the coordination project is organized around three major outputs: 1) development, use, monitoring and adaptation of the impact pathways (Outcome Logic Models); 2) innovative approaches to foster change by mapping networks of present and desired actors and their interactions and developing plans for engaging and influencing them; and 3) communication among RWM actors and between policymakers and development actors, and among all partners within the five projects as well as other local and national initiatives. The project also emphasizes two crosscutting areas, capacity building and mainstreaming gender into the RWM agenda. The coordination project ensures a high level synthesis of lessons and processes relevant to the broader research and development communities that facilitate successful scaling up and out of RWM strategies.

1.2 Purpose of this paper

Ethiopia has many decades of experience implementing programs and projects aimed at improving water and land management. Some of these have been very large, others relatively small projects. During the same period, national and international research organizations have been carrying out research programs aimed at achieving a good scientific understanding of the nature of the problem, the problems and challenges facing implementation programs, and the potential solutions. Over time, the implementation strategies of government and NGO programs have evolved, informed by experience and research results. Government policies and institutional arrangements have also undergone important changes over time, based on lessons learned. Today there are literally hundreds if not thousands of reports, theses, books, and journal articles reporting the results of both the implementation and research programs. However, this material is scattered and much of it not easily available. More important, while there are some attempts to synthesize results and lessons from specific projects or with regard to specific topics, there are no broad comprehensive

assessments of the outcomes and lessons learned from all this experience. This is unfortunate because there is a danger that the CPWF or indeed other research and development programs will repeat mistakes made in the past, or re-learn lessons already learned by others.

Therefore, this paper is an attempt to draw together and synthesize as much of the existing documentation as is possible within a limited time period, analyze it systematically, and draw out the main conclusions, lessons learned, and gaps in knowledge. As noted above, the report tries to identify which RWM innovations have worked when, where and why; what did not work out very well, and why; and what lessons can be extracted from past experience to guide CPWF research in the Nile over the next 4-5 years. It takes a broad approach, addressing policy and institutional issues at multiple levels, experiences and lessons from major implementation and research programs, the outcomes and impacts of specific RWM interventions, experiences with targeting, and other topics. The paper also makes recommendations intended to provide support to the planning and implementation of CPWF Projects N2-N5 as well as other research for development programs.

In short, the report contains the findings and recommendations of the study, including, as stated in the terms of reference:

- Summaries of the findings of past and on-going studies on RWM strategies, including
    - Impacts on water productivity,
    - Success as well as failure in improving agricultural production and livelihoods – and the reasons for these,
    - Negative as well as positive social and environmental impacts (e.g. upstream-downstream consequences, increasing transmission of vector borne disease),
    - Analysis of factors influencing RWM management adoption or dis-adoption behavior, including an analysis of policy or institutional factors at different levels (local, regional, federal) that may directly or indirectly influence the use of improved RWM strategies.
- An inventory of institutions and individuals working in the past and in the present on RWM – and which of these might be suitable CPWF BDC partners (see Annexes in volume 2).

1.3 Overview: Structure of the paper

Section 2 discusses some of the key concepts used in this report, the research questions that have guided the work, the methodology and approach used including its limitations, and the sources of the data. Section 3 briefly sets the scene with regard to Ethiopia, the Blue Nile, and the Nile River Basin. Section 4 examines the evolution and to some extent effectiveness of Ethiopia's institutional and policy framework for rainwater management. This includes the governmental structure, which has changed radically since the 1970s; its agricultural, water and other policies and implementation strategies – which have also evolved rapidly; and the major development, nongovernment and research organizations active in RWM. Section 5 analyzes the evolution, outcomes and lessons learned of the major RWM development programs (largely governmental), as command and control (coercion) gives way to bribed (sometimes coerced) participation and in some cases genuine local empowerment. Section 6 reviews the evolution, outcomes, findings and impacts of some of the major RWM research and development programs. Section 7 assesses the results and impacts of selected specific rainwater management and soil and water conservation interventions – and finds these results are often contradictory and/or site-specific. Section 8 addresses the issue of targeting RWM interventions in terms of agro-ecology, development domains and social categories such as

gender. Section 9 attempts to consolidate the major lessons learned, with an emphasis on specifying both what works and under what conditions, and what are the main lessons for guiding the next generation of RWM research in a landscape or integrated watershed perspective. Finally, section 10 synthesizes the key conclusions and recommendations.

The main report is contained in volume 1 of the report. The appendices, mainly a set of detailed tables, are contained in volume 2.

2. Concepts, Methodology and Sources Used

2.1 What is meant by "landscape approach to rainwater management" and other concepts?

The term "Agricultural Water Management" (AWM) has come to be defined in a broad manner, to include management of water for crops, agro forestry, livestock and fish in the continuum of agricultural systems ranging from full irrigation to those dependent entirely on rainfall. Most Sub-Saharan African (SSA) smallholder farmers depend on rainfed agriculture; and most staple grains are rainfed. Rainfed agriculture is by definition dependent on the timing and amount of rainfall; and in most regions of Africa rainfall is highly variable and unreliable. This is the case even in areas with relatively high average rainfall, such as the East African Highlands. This is a major factor underlying low productivity: even if input and output markets are operating and farmers have access to improved seed and fertilizer, they are still reluctant to invest because of the high risk of loss. In much of SSA markets do not operate well, and until recently governments have under-invested in agricultural support. Farmers' risk aversion is a rational strategy in this situation. The result is low productivity of rainfed agriculture, high levels of poverty and poor health, high levels of vulnerability to shocks such as drought or illness, and continuous under-investment in sustaining the productivity of the natural resource base – a perfect vicious cycle.

Nevertheless, as emphasized by the Comprehensive Assessment of Water Management in Agriculture and other studies, most of the additional food production in the future must come from rainfed agriculture; and there is a huge potential for reversing the present vicious circle by investing in improved water, land and crop management in rainfed systems (Rockström et al 2007, 2010; Bossio et al 2007, 2010; and others). Rainfed agriculture can be upgraded by improving soil moisture conservation and, where feasible, providing supplemental irrigation, if combined with improved fertility and crop management in a context where farmers can benefit from such investments. The critical requirement is to take an integrated and holistic approach and avoid focusing too narrowly on one dimension, be it water, soil, or crop variety. In this context, the CPWF has therefore adopted the term "*rain water management*" (RWM), defined broadly to include soil and water conservation (SWC), *in situ* and *ex situ* rainwater harvesting, conservation farming, and small-scale irrigation as well as better fertility and crop management. It focuses on livestock, trees and fish as well as crops. A *rainwater management system* (RWMS) therefore includes technologies and practices for managing land and water for production, and the policy, institutional and social dynamics and support systems necessary to optimize the benefits of such technologies and practices. RWM focuses attention on management of *water*. However, other researchers and implementing agencies focus more attention on management of *land*. As discussed in more detail below, several decades of research and implementation programs in the Ethiopian highlands have documented the

rapid degradation of land through soil erosion and nutrient mining: it is land degradation that is seen by many as the most serious threat to sustainable development and its reversal as a high priority investment (see articles in Pender et al, eds, 2006; Bossio & Geheb, eds, 2008; Wani et al, eds, 2009). Therefore there is a need for "sustainable land management" (SLM). In reality, "*every land-use decision is a water-use decision. Improving water management in agriculture and the livelihoods of the rural poor requires mitigating or preventing land degradation*." (Bossio et al 2007:551; italics in original). Many of Ethiopia's current programs address "SLM" but the concept is to be understood as a variation on "RWM" as both basically include the same technologies and practices[3]. The difference is that SLM tends to focus on reversing land degradation as a goal, while RWM has a goal focused explicitly on improving productivity while also maintaining land and water resources.

Water and land are managed at multiple scales and levels: farm plots, small or micro-watersheds nested in larger watersheds, and ultimately large river basins. At all of these levels, *integrated management* of land, crops, livestock, water, forestry, agro-forestry, and people are essential. Based on concepts of integrated natural resource management and integrated water resource management, the term "integrated watershed management" (IWM) is the conceptual foundation of most modern programs to improve water and land management, especially in highland areas characterized by sloping lands. Watersheds often include a combination of individual farm plots and commons. Obtaining the maximum benefits from improved resource management requires the people of that watershed to collaborate with each other, and often with outside parties providing services as well. The concept and practice of IWM has been evolving for several decades, becoming more people-centered, and increasingly "embedded" in broader sustainable development processes (FAO 2006). Often the interests of downstream and upstream watershed stakeholders diverge, necessitating negotiated solutions or subsidies to align stakeholders' incentives. Payment for Environmental Services (PES) is emerging in some regions of the world as a viable approach to offering incentives for upland conservation and may have potential in the Nile (Alemayhu et al 2008).

As noted above, the CPWF objective is "*to increase the productivity of water . . .*". "Water productivity" (WP) is a concept that is easy to define but very difficult to measure and apply. Water productivity is simply the amount of crop, livestock or other product, or value in monetary terms produced per unit of water that is consumed (or applied) (see Molden et al 2007; 2010). During phase 1 of the CPWF, the concept has been adapted to cover livestock – "livestock water productivity" (LWP) (Peden et al 2007; Haileselassie et al 2009a; Descheemaeker et al 2010). LWP is complex because it is multi-dimensional: in addition to water for drinking, the inputs include water for feed production, itself a complex issue depending on the source of feed. Livestock management practices can lead to resource degradation (for example by over-grazing); and there are multiple outputs to measure. Nevertheless, in mixed crop-livestock systems such as those characterizing the Ethiopian highlands, improved management of livestock can produce very valuable outputs per unit of water. A final related concept is "multiple use water services" (MUS): phase 1 of the CPWF has made major contributions to identifying the substantial benefits that are possible by replacing the design and implementation of single-use water schemes to multiple-use: schemes that seek to

[3] "SLWM" (Sustainable and Water Management) is another term, used by the Comprehensive Africa Agriculture Development Program (CAADP).

satisfy the diverse water needs of people for productive and other purposes (Nguyen-Khoa et al 2008).

This paper generally uses the term "institution" to refer to social arrangements -- rules, norms – that shape and regulate behavior and persist, i.e., have some degree of permanence and purpose that transcend individual lives and intentions. Institutional economists refer to institutions as 'the rules of the game in society' (North 1990). The term *organization* is used to refer to groups of people with shared goals and some level of formalized patterns of interaction defined in terms of "roles" (Merrey et al. 2007: Box 5.1). Sometimes, consistent with common usage, the term "institution" is used in a broader sense to encompass both concepts – i.e., rules and groups of people.

2.2 Innovation systems

It is now widely recognized that the old model of specialized research institutions "doing" research, separated from institutions providing extension, capacity building and technical support services, does not work well. Similarly, projects with no built-in learning system often fail to achieve their full potential. Increasingly, an approach called "innovation systems" is being pursued. There is a large literature on "innovation systems" in industrial countries but the concept has been applied to agricultural research in developing countries only recently[4]. An "*innovation system*" is defined as a set of organizations and other interested parties with stakes in developing and using new technologies, institutional forms, and practices. It links policy-makers, potential clients or users (demand side), researchers (supply side), and various other stakeholders, for example those who may be providing the product or support services as manufacturers or retailers, and those who may be beneficiaries (who may be different from the users). Analytically, it focuses on "the processes by which diverse agents engage in generating, disseminating, and utilizing knowledge, the organizational and individual competencies of such agents, the nature and character of their interactions, and the market and nonmarket institutions that affect the innovation process" (Spielman 2005:10).

"Learning Alliances" are a variant of innovation systems pioneered by CIAT and more recently by the CPWF through its project on Multiple Use Water Services Systems (van Koppen et al. 2006; Smits et al. 2007; Butterworth et al. 2008; see also www.musgroup.net). They are different from "communities of practice" because they include a range of diverse stakeholders, especially potential users, while communities of practice tend to include a limited set of role players, for example researchers only. Learning alliances are intended to overcome institutional and conceptual barriers among participants (such as researchers, communities and implementing agencies) having a shared vested interest in solving an agreed problem. Whichever term is used, the central point is that "innovation," defined as "new information introduced into and utilized in an economic or social process" (Spielman 2005:12), is rarely a linear process going from researcher to users to beneficiary, especially in the case of complex systems where the innovation may be a set of practices and behaviors combined with a technology that requires changing relationships as well. A mutual "learning process" based on partnerships is required. The various interested parties therefore participate in the processes of conceptualizing, development, testing, adaptation and scaling out innovations in a mode through which all are learning together — hence "learning alliance". An R&D

[4] Fagerberg et al. 2006 provide a recent comprehensive perspective on innovation.

innovation system or learning alliance can also make use of a growing range of tools for enhancing impacts, for example through value chain analysis and "impact pathway analysis" – attempts to identify from the beginning how an innovation will be developed, shared, disseminated, and have real outcomes and impacts.

Clearly, an innovation system approach includes (but conceptually goes beyond) participatory research with farmers; it also includes the concept of building upon farmers' own indigenous knowledge wherever possible rather than proposing "scientific" alternatives. However, to implement research and development through innovation system perspectives also requires the researchers to have an in-depth understanding of farmers' views and perspectives, rural social networks, and the complex adaptive agro-ecology within which farmers operate (Hall & Clark 2010; Waters-Bayer & Bayer 2009; Matuschke 2008; Spielman et al 2008). The analysis in this paper examines Ethiopian RWM experiences through a participatory "innovation systems" perspective. We return to "innovation systems" as part of our discussion of CPWF phase 2, below (section 9).

2.3 Research questions

The terms of reference for Project N1 pose the following broad questions:

- What is known from past experience about designing and implementing successful rain water management programs in the Ethiopian Highlands (both developmental and research and development programs)?
- What is known from past experience about spatial targeting of different RMS to different environments?
- Who else is working on rainwater management and how can we most effectively link up with them?

Additional questions suggested subsequently are:

- What are consequences of RWM locally and in upstream downstream linkages based on evidence from the region and other places of the world?
- Which analytical tools and models have proven most useful in Ethiopia?

The TOR anticipated these questions would be refined as the study got underway. During the planning period, we developed a detailed list of questions that have guided the study and presentation of the findings. The tables contained in the Annexes (volume 2) reflect the ten categories of questions, as does the structure of the annotated bibliography table (Annex Table 1). The detailed questions are provided in Annex 1, while Box 1 summarizes the ten categories of research questions.

The study has not addressed all of these equally. For example, with a few exceptions, we have not found much documentation on the effectiveness of NGOs as RWM implementing agencies and therefore cannot answer the question on implementing agencies fully; and we have only partially been able to evaluate the various tools and models used in understanding the impacts and outcomes of RWM interventions. The research questions driving this study are closely linked to the research questions to be addressed in Projects N2, N3, and to some degree N4; and their answers support achieving the planned outcomes of Project N5 (see Annex 1).

2.3 Methodology, approach and limitations

The first step was developing and sharing with the leaders of Nile Projects 2-5 the refined research questions for comments and suggestions. Based on these questions, a set of tables was developed (see volume 2) as a guide to recording basic information under appropriate categories. The authors spent a week in early May 2010 meeting the leaders of the other projects as well as interviewing as

Box 1: Summarized Research Questions

1. **Policies:** What are the main government policies related to RWM and how have they evolved over the past two decades? What are the strengths and weaknesses currently?
2. **Institutional framework for policy implementation:** What are the main features and strengths and weaknesses of the institutional framework, from national to local levels, in place to implement government policies towards RWM?
3. **Main RWM development programs:** What have been the major past and current RWM development programs and projects promoting improved RWM in the Ethiopian Highlands (specifically, the Blue Nile Basin) and what have been the main results and lessons?
4. **Main RWM research programs:** What have been the major RWM research programs and projects in the Blue Nile/Ethiopian Highlands, what have been the major findings and how have they been used?
5. **Promising RWM interventions:** Based on experience in Ethiopia and 'expert knowledge' what are the most promising interventions (technologies, practices)?
6. **RWM implementation strategies and institutional innovations:** Based on past experiences, what implementation strategies and institutional arrangements have been used to promote RWM interventions and what has been the experience and results of each?
7. **Main types of RWM implementing agencies and their effectiveness:** Based on past experiences, what types of actors are most effective in promoting or supporting the promotion of RWM interventions?
8. **Experience with targeting:** What have been the experience and lessons learned, with regard to targeting of RWM interventions (including agro-ecological, development domains, social categories)?
9. **Tools and models:** What types of tools, methods and models are used to understand the impacts and consequences of RWM interventions in the past?
10. **Institutional innovations not yet tested:** Are there potential institutional innovations that have yet to be tested in the context of the Ethiopian Blue Nile basin?

many key informants based in Addis Ababa as possible. We also used this opportunity to obtain and share documents — research reports, project reports, policy statements, journal articles, theses, etc. The second author continued this process after the departure of the first author from Addis.

A very large amount of time has been devoted to collecting and reviewing the documents. In addition to those obtained in Addis, additional documents were obtained from other colleagues, a variety of websites, the IWMI library, the authors' own collections, and IFAD headquarters (during a visit to Rome for another assignment). Most though not all are in electronic form. Therefore, one additional product of this study is an electronic data base of sources organized in terms of the categories of research questions. Annex Table 1 lists approximately 390 references but it is clear this is by no means complete. This is an indication that a great deal of work has been done, which provides a good foundation for the second phase of CPWF in the Blue Nile. However, this also offers a challenge – adding value in a situation where so many have already worked.

There are important limitations and gaps in this report. First, the time available was short, and there was no time at all for field visits. Second, although we have reviewed a large number of documents, the database of sources is by no means complete. There are other research and project reports not included here because we could not gain access to them. For example, with few exceptions we found it difficult to obtain financial institutions' project completion reports and external evaluations of outcomes and lessons learned; and very few of the major research programs have published systematic descriptions of project outcomes and impacts. A specific gap is that we found relatively little documentation of the experiences of NGOs in RWM with the partial exception of government-sponsored NGOs (e.g., ORDA, REST). We have not included small scale communal irrigation in the study, as these constitute a separate issue (though there are now sufficient studies to take stock of what is known as a prelude to further research; see Annex Table 1). Despite these gaps, the other side of the coin is that the amount of material to be read and analyzed was quite staggering, especially since much of it was new at least to the first author.

Fortunately, this draft report has been reviewed by the CPWF including the Nile Project N2-5 researchers; and its main findings were also presented at a NBDC launching workshop on 29th September 2010. The feedback received has been used to finalize the report and to refine the conclusions and recommendations.

2.4 Sources

Table 1 in the Annex is a list of all the references consulted in the course of this study. Those used explicitly in this report are listed in the references section, below. The available literature is clearly enormous, though of varying quality. It includes quite a few excellent research studies in the form of journal articles, working papers, M.Sc. and Ph.D. theses, and books. A great deal of this literature has been produced by scholars associated with European universities working in collaboration with Ethiopian institutions, often producing detailed case studies as Ph.D. theses and refereed journal articles. In the past twenty years, CGIAR centers, especially IFPRI and ILRI, and more recently IWMI, also working with Ethiopian institutions, have produced excellent research products addressing RWM in Ethiopia including the Blue Nile area. This work has spanned a broad set of disciplines and has also included integrated interdisciplinary research. A fair portion of this work has enabled Ethiopian students to obtain advanced degrees, thus contributing substantially to building Ethiopian capacity. In addition, many of the projects and programs supported by development partners have produced useful and important analyses in the form of project appraisals, reports on outcomes and impacts, project completion reports, and external assessments of project outcomes. These projects and indeed the government agencies themselves have also produced a number of training modules, handbooks for guiding implementation, etc. The government of Ethiopia has produced a large

number of policy, planning and implementation strategy documents and the like as well. Not surprisingly the quality and usefulness of all these sources vary considerably. Nevertheless, taken as a whole, there is a remarkably large and useful body of material on which to draw to assess what has been learned, what works and what does not and why, regarding RWM in Ethiopia.

3. Setting the Scene: Ethiopia, the Blue Nile, and the Nile River Basin

3.1 People, landscapes and the roots of rural poverty

Over several millennia of recorded history, Ethiopia has developed its own distinctive cultures, languages and identity. Its ancient rulers built magnificent churches, monasteries, and palaces, many of which are today protected by international conventions. But by modern times, a political system centered on an emperor and a tiny elite who controlled most of the land and other resources was failing to promote broad-based economic and social development. Agricultural productivity had stagnated even as population grew; per capita food production declined continuously during the 1960s-1980s (Webb & Braun 1994: 32, Figure 3.1). Farmers did not adopt productivity-enhancing technologies and therefore cultivation was extended into increasingly steep and inappropriate areas, leading to deforestation and soil degradation. Periodic famines have characterized Ethiopia throughout its history; between 1960 and 1994 Webb & Braun (1994: 20-21, Table 2.1) record at least ten severe famines, most of them in the northern highlands (as well as the western lowlands). In 1970-1975 a series of failures of the rain led to especially severe drought and famine (1973-1975); an estimated 250,000 people may have perished during this period, mostly in Eritrea, Tigray and parts of Amhara (Webb & Braun 1994: 27). The emperor was deposed and replaced by a radical military regime (the "*Derg*") inspired by "communism" in 1974. It implemented major reforms, for example nationalizing land and attempting to re-organize the rural people by dismantling the feudal system, introducing cooperatives (collective production systems through villagization programs) and state-owned farms. It also expanded the research and extension systems initiated by the previous government. Unfortunately, drought and famine continued periodically in the 1980s with high death tolls and other devastating short and long term impacts, the turmoil of civil war continued, many of the new government's policies were flawed and its implementation capacity was limited. Except for humanitarian relief, Ethiopia had lost the support of most western development partners until the early 1990s when the current government overthrew the *Derg* and came to power. Since then the new government has stabilized the country, creating an entirely new decentralized federal government under a new constitution, and developing social and economic development policies that have attracted enormous amounts of international support. By most measures Ethiopia has made impressive progress since the early 1990s, but it has to be understood the country is basically "catching up" on several decades of lost time.

Today, with a population exceeding 80 million people, Ethiopia is the second largest country in sub-Saharan Africa. Its population is currently increasing at a rate of nearly 3% per year, challenging the capacity of the country to provide basic social services and employment, and continuing to put pressure on natural resources. With a *per capita* income of about $780 (in purchasing power parity terms), Ethiopia remains one of the poorest countries in the world; in 2009 Ethiopia's Human Developing Index (HDI) was 0.414, giving it a rank of 171st out of 182 countries with data. Life

expectancy at birth is only about 55 years[5]; though improving, maternal mortality and child nutrition rates are among the highest in the world; only about 30% of the population has access to clean drinking water; and over 12 million people are food-insecure (IFAD 2008). The latter figure fluctuates with annual agricultural production – which remains largely a function of variations in rainfall as nearly all staple food is grown under rainfed conditions. Over the past 30 years, per capita food production in Ethiopia has declined from 280 kg to about 160 kg per year (Awulachew 2010). Much of the population lives below the national poverty line, with the overwhelming majority of poor people living in rural areas — most rural households survive on a daily income of less than US$ 0.50. Nevertheless, the government notes that the rate of economic growth has been very high overall during the 21st century, and agricultural growth has also been substantial despite continuing major fluctuations largely caused by drought[6], leading to considerable progress in poverty reduction albeit from a low base (from an estimated 48% in 1990-91 to 34.6% in 2006-07 according to the Ministry of Finance and Economic Development ([MOFED 2008b])[7].

Ethiopia's economy is dominated by agriculture: it contributes nearly half of GDP, 90% of exports, and absorbs 75-85% of the labor force—a figure that is high even by SSA standards (AfDB 2008:5-6). But labor productivity in agriculture remains low and is increasing at a low rate; yields are also increasing slowly, with average staple cereal yields stagnating at 1.15 tons per hectare. IFAD (2008:3) attributes this to limited access to financial services, markets, and improved technologies such as irrigation and better crop varieties, and "to poor land management practices that have led to severe land degradation." The African Development Bank (AfDB 2008:6) notes the following:

> Ethiopian agriculture is characterized by (1) varied ecology and dependency on climate and natural resources as source of growth; (2) undercapitalization of infrastructure and indigenous capacity to generate technical change on continuous basis; (3) high transaction costs and low market transactions, particularly in areas remote and sparsely populated; (4) prevalence of major agricultural commodities with wide potential national market but remain largely nontradable; (5) considerable risk arising from its dependency on rainfall, high transaction costs and price risks; and (6) rising population burden due to population momentum and declining adult population in total population due to epidemic diseases.

Ethiopian agriculture is largely dominated by low input-low output rainfed farming systems focused primarily on subsistence. These systems are largely mixed crop-livestock systems, but the livestock are more often oxen for land preparation and transport rather than for dairy or meat. In the arid lowlands, pastoral agricultural systems predominate; while even in the highlands transhumance is not an uncommon adaptation (Nyssen et al 2007; Tegegne et al 2009). This study has however focused on the settled mixed crop-livestock systems. Another defining characteristic is the diversity of agro-ecological zones, ranging from the highlands with their high population density, generally higher rainfall and lower temperatures, to the sparsely populated lowlands. This diversity has multiple dimensions including variations in soils, rainfall, altitude, temperature, market access,

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[5] These figures are from UNDP (accessed 22 July 2010): http://hdrstats.undp.org/en/countries/country_fact_sheets/cty_fs_ETH.html.

[6] Recent agricultural growth rates: 2001/02: -2.1%; 2002/03: -11.4%; 2003/04: 17.3; and 2004/05: 13.4% (MOFED 2006a).

[7] Bevan & Pankhurst (2008) provide an interesting de-construction of the multiple "causes" of poverty found in most official documents, as an aid to better targeting of poverty-reduction programs.

population densities, and culture (ethnicity). The Highlands, representing up to 50% of the total land area of the country and home to up to 90% of its population, is often referred to as a "water tower" because all of Ethiopia's 12 major rivers, including most of the waters of the Nile, originate here. Yet even here, rainfall is so variable and unreliable that agricultural water management is critical to productive agriculture. Perhaps more important, it is in the highlands that land degradation is most serious, threatening the future viability of both highland agriculture through loss of nutrients, soil and vegetation, and lowland agriculture through siltation of infrastructure, flash flooding and pollution. This diversity also has important implications for agricultural development strategies. These issues are discussed further below.

3.2 Land degradation in the Ethiopian Highlands

The population of the Ethiopian Highlands had been increasing for centuries. Despite some out-migration, the result has been rising population densities, extension of cultivation into steeper lands and former forests leading to soil erosion and shortage of fuelwood, and reduction in fallow periods. Resource-enhancing technologies were not widely adopted. People were thus increasingly vulnerable to shocks such as floods and drought. The famines of the 1970s and 1980s brought to the attention of the government and the international community how serious land degradation had become; it was noted at that time that the areas with the highest rates of annual soil degradation were closely related to the most famine-prone zones of the northern highlands (an observation that may no longer be correct). As a result, the Ministry of Agriculture with support from the World Bank commissioned the "Ethiopian Highlands Reclamation Study" (EHRS) implemented by FAO (FAO 1986a, 1986b[8]). The EHRS was a very comprehensive assessment of land degradation problems, including discussions of history, government structure and policies, agriculture, economy, and the various programs and projects related to land conservation as of the 1980s. It has become the 'benchmark' for all studies of land management since then. Its estimates of soil erosion rates are authoritative and still quoted, though other work since that time has refined its rather global and possibly exaggerated estimates. FAO (1986a) estimated that some 1,900 million (1.9 billion) tons of soil were being eroded annually from the Highlands, equivalent to 35 tons/ha (total area) or an estimated 130 tons/ha of cropland. Even allowing for re-deposition of some of this soil on crop lands downhill, FAO estimated that the Highlands were losing some 1,100 million tons of cropland soils annually. Again, much of this was assumed to be deposited on grass and forestlands, with rivers carrying away about 190 million tons of soil per year. FAO (1986a:183) claimed its figures were consistent with measurements from other studies. Most losses were estimated to be from croplands, a result both of cultivation on steep slopes and multiple plowings especially for teff, often at angles to the contour, leaving soils exposed to erosive rain. FAO (1986a:190, 200) offered alarming projections of the likely impacts on soil depth leading to an additional 76,000 km^2 incapable of being cropped (on top of the estimated 20,000 km^2 already lost); the annual costs to Ethiopia over the following 25 years were estimated to be 2% of GDP in 1982/83. Some estimates of impact on GDP have been even higher; but field research combined with improved methodologies since the 1980s has refined these projections. The point here is that such authoritative reports documenting

[8] The two main volumes plus 27 working papers provide a wealth of detailed information on many topics. While volume 1 is a detailed situation analysis, volume 2 provides detailed and comprehensive proposals on measures to reverse land degradation and improve agricultural productivity. EHRS and SCRP are discussed further in section 6, below.

catastrophic land degradation processes have provided the foundation for the huge investments to reverse these trends.

A longer term research and capacity building program was also launched during the 1980s, the Soil Conservation Research Project (SCRP). Its purpose was to carry out long term monitoring of land-use changes, land degradation, and sustainable land management (eventually done on seven[9] sites). It was intended to provide basic data for implementing SWC interventions, test proposed measures, build a National Soil Conservation Research Unit within the Ministry of Agriculture (MoA), and train local and international personnel. It was implemented by the University of Berne and MoA; and is discussed further in section 6, below. FAO's reports drew heavily on initial results from SCRP. FAO (1986a:216-217) lists a number of additional externally assisted programs underway in the 1980s. Since that time, there have been numerous other studies on specific watersheds to measure soil erosion rates and impacts and a large number of publications (e.g., Hurni et al 2005; Awulachew et al 2008a, c; Awulachew & Tenaw 2009; summary in Hagos et al 2009; Awulachew 2010; Zegeye et al 2009). The perception that soil erosion is a dire threat to the future of Ethiopia remains high, combined with concerns over nutrient mining, deforestation, potential impacts of climate change, and the need to manage water *and* land in an integrated manner from farm plot to micro-watershed to river basin levels. Specific findings on soil degradation and impacts of introducing a variety of soil and land management (SLM) and AWM practices are discussed in more detail below (section 7).

3.3 The Abay (Blue Nile) River Basin

Three major river basins flow out of Ethiopia into Sudan, constituting the Eastern Nile Basin, as distinct from the White Nile flowing from the south. These are the Tekezi-Atbara flowing out of northern Ethiopia, the Baro-Akoba-Sobat flowing from southern Ethiopia, and the Blue Nile (Abay) sandwiched between the other two. The Blue Nile Basin covers an estimated area of 311,437 km^2 and is shared by Ethiopia and Sudan; it joins the White Nile in Khartoum, Sudan. The Baro-Akoba-Soba joins the White Nile about 800 km above the Blue Nile, while the Tekezi-Atbara joins the Blue Nile below the border with Sudan (Hydrosult 2007a). The Blue Nile is located between 160 2' N and 70 40' N latitude, and 320 30' E and 390 49' E longitude. Its source is in Gish Abay, West Gojam from where it flows north into Lake Tana. The Blue Nile – known as the Abay in Ethiopia — exits from the Lake and flows south, then westwards, cutting a deep gorge toward the western part of Ethiopia. A number of tributaries join it in Ethiopia as well. In Sudan it flows across a relatively flat desert to Khartoum (Yilma & Awulachew 2009). The Ethiopian portion of the Blue Nile basin – hereafter the Abay — covers nearly 200,000 km^2 and accounts for a major share of the country's irrigation and hydropower potential[10]. It has an average annual run-off estimated at 54.8 billion cubic meters (BCM) and accounts for approximately 40% of Ethiopia's total surface water resources (Awulachew et al 2008a referencing World Bank 2006a). Its topography is characterized by rugged mountainous highlands in the eastern and central portion of the basin, with altitudes ranging from 1000-1500 masl to 4260 masl and a slope of over 25% in the eastern portion. The Ethiopian lowlands are relatively flat, with slopes generally under 7%. Similarly, the highlands have the highest rainfall, often ranging from 1500 to 2200 mm (but with some areas as low as 800 mm), while the lowlands have less than 1500 mm—often substantially less – of rainfall on average. The lowlands have the

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[9] Includes one site in present-day Eritrea.

[10] Hydrosult 2006:25 gives 202,989 km^2 as the area of the Abay, 88,501 km^2 for the Tekezi/Abara, and 75,856 km^2 for the Baro-Akobo.

highest average temperatures (15-38° C is the range) while the highlands have far lower average temperatures (-1-20° C). The population of the Abay Basin is approximately 27 million, about 34% of Ethiopia's total population, with high densities in the highlands and relatively low densities in the lowlands (Figure 1). There are 16 sub-basins in the Abay; their main features are described in Yilma & Awulachew 2009.

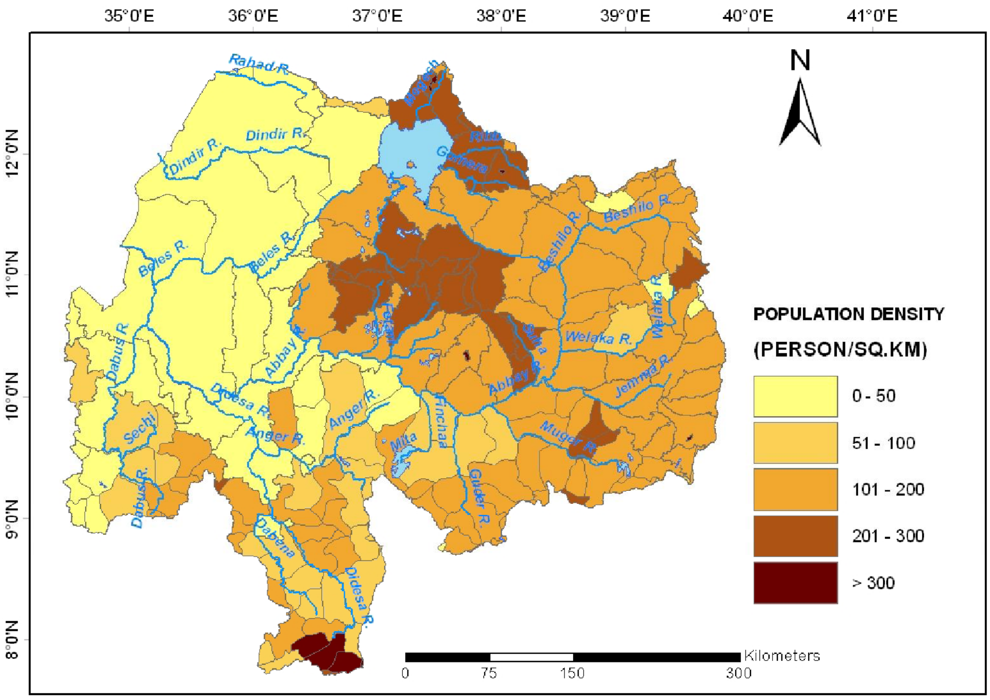

Figure 1. Population densities in the Abay Basin
Source: Central Statistical Agency 2007, reproduced in Yilma & Awulachew 2009: 35, Figure 48.

The Tekezi drains a large portion of Tigray National Regional State, while the Abay drains much of Amhara National Regional State, portions of Tigray and Oromiya, and much of Beneshangul-Gumuz. The Baro-Akoba is centered on Gambela, plus parts of its neighboring states. The highlands of the Tekezi and northeastern and eastern highlands of the Abay Basin include many areas with severe structural food deficits, made worse by periodic reductions in production because of low rainfall. This low and declining productivity is part of a vicious cycle of soil erosion, nutrient depletion worsened by burning of dung, deficits in livestock feed and high levels of fuel wood consumption resulting in deforestation in a context where there are few off-farm employment opportunities. The good news is that in recent years Tigray has had considerable success in promoting soil and water conservation programs that have had visible positive local impacts (Hydrosult 2006). The western highlands of the Abay are also characterized by high population densities, but with higher and more stable rainfall and better soils enabling higher crop production than the Tekezi. Nevertheless, this area too is facing serious erosion on steep slopes and devastating soil nutrient depletion; and rainfall is not entirely reliable.

There are several recent reviews of soil erosion in the Abay River Basin (including Hydrosult 2007a; Awulachew et al 2008a, 2010); and a growing number of case studies of land use changes and their impacts on specific sub-watersheds (e.g., Tegegne 2002; Bewket 2003; Beshah 2003; Amsalu 2006; Awulachew 2008c; Awulachew & Tenaw 2009; Zegeye et al 2009; Nyssen et al 2009). An estimated

302.8 million tons of soil is eroded in the basin annually, largely through sheet erosion; of this about two thirds is from uncultivated land, i.e., communal grazing and settlement areas. Awulachew et al (2008a:28-29) estimate 55% of this soil remains in the landscape (Hydrosult 2007a: 81-82 estimates 61%) – an estimate considerably lower than EHRS and other estimates. Over 2 million ha of cultivated land in the Highlands exhibits unsustainable soil erosion rates. Hydrosult (2007) estimates the annual reduction in grain yields in the basin from soil erosion is about 25,190 tons, 0.6% of the total—but this cumulates over the years; after 10 years it rises to 6% and after 25 years to 15% of annual crop production. This does not include additional losses resulting from soil nutrient mining. Awulachew (2010) reports detailed research on small sub-basins in the Upper Abay, and documents considerable variation in sediment yields. This variation depends on five factors: rainfall and runoff, soil erodibility, slope length and steepness, cropping and soil management, vegetative cover, and support provided to prevent erosion. The sub-basins with the highest sediment yields were all dominated by crop agriculture on about 95% of their surface[11]. As Haileslassie et al (2008:16) state, "The problem is mainly in the *small grain cereal-based farming systems*" [italics in original].

There is a large and rapidly growing body of research on both macro and micro level hydrological and other trends and opportunities in the Ethiopian portion of the Abay River Basin – far too large to review completely here. The basin is critically important to Ethiopia itself, in view of the combination of large population, huge development potential, and massive natural resource degradation characterizing the basin. It is no less critical to Sudan and Egypt downstream, as it is the source of about 62% of the Nile flow into the two countries (the three main sub-basins of the Eastern Nile together account for about 86% of the water flow and possibly 100% of the silt threatening the viability and existence of downstream dams and canals). As discussed briefly in the next section, the three countries are cooperating on a range of studies and investments within the context of the Nile Basin Initiative (NBI). The best single overview of the Blue Nile from the perspective of AWM opportunities is the final report from the CPWF Basin Focal Project (Molden et al 2009). Awulachew et al (2008a, b) offer useful reviews of water availability and its allocation in the Blue Nile, while Block et al (2007, 2008a, b) use modeling tools to assess planned investments in hydropower, irrigation and other infrastructure in view of the potential impacts of climate variability and change: perhaps fortunately for the basin countries, at least one modeling exercise suggests the region will not see major deleterious effects on water availability by 2050 (Kim et al 2008) – though others place greater emphasis on the high degree of uncertainty regarding future hydrology (see McCartney et al 2010 and references therein). In addition to the Basin Focal Project, the CPWF projects on livestock water productivity and upstream-downstream interactions (Peden et al 2009a; Awulachew 2010) have provided useful research-based data on the Abay Basin. This paper draws on these and numerous other studies below. The World Bank's (2006a) country water resources strategy offers an excellent analysis of the challenges and opportunities presented by Ethiopia's "difficult" hydrology.

There are also numerous development investment projects underway in the Abay Basin. Those specifically focused on the Abay with important AWM components include: the Tana Beles Integrated Water Resources Development Project (World Bank), Koga Irrigation and Watershed Management Project (AfDB), and Community-Based Integrated Natural Resource Project in the Tana

[11] This observation seems to contradict the point earlier in this paragraph that about two thirds of all sediment load is from uncultivated areas.

Lake sub-basin (IFAD & GEF). Other national investment programs include investments in the Abay as well. These programs are discussed further in section 5, below.

Yet, with all this potential and all these investment projects and research studies, Awulachew et al (2008a:6) state that "Currently, the Abay is one of the least planned and managed sub-basins of the Nile." They note that about 2/3rds of the basin falls within the highlands. This portion receives high levels of rainfall on average, but it is extremely erratic both spatially and temporally, with frequent dry spells whose effects on crop production and livestock can be catastrophic. A large percentage of Ethiopia's food-insecure population lives in the Abay Basin highlands; and land degradation is now considered to be the most serious threat to long-term development. Reversing these negative trends would make a significant contribution to sustainable development and improving peoples' lives in Ethiopia while also benefiting downstream basin residents. Fortunately, much has been learned in the past several decades from both research and development programs. This knowledge provides a strong foundation for phase 2 of the CPWF to meet its Nile Basin Development Challenge, "to improve rural livelihoods and their resilience through a landscape approach to rainwater management."

3.4 The Nile Basin Initiative

At 6,700 km, the Nile is the longest river in the world. It has a catchment of some 3.3 million km^2 shared by ten countries with very different interests and views on how the Nile Basin should be developed and used. The Basin contains enormous water and other resources that provide the basis for potential mutually beneficial development; but there are also daunting challenges as the inhabitants include some of the poorest countries in the world and there had been no history of cooperation except between Sudan and Egypt. The Nile Basin Initiative (NBI) was launched in 1999 with strong international support: nine of the ten countries are members (Eritrea is an observer). Its secretariat is in Entebbe, Uganda. Over time the nine countries have come to share a vision for cooperating to achieve peace, sustainable development and environmental protection. Based on this vision, the countries have been implementing a Shared Vision Program (SVP) and two investment Subsidiary Action Programs (SAPs). The SVP has eight component projects largely involving joint studies and capacity building, most of them completed by this time; one, the Efficient Water Use for Agriculture Project (EWUAP), is discussed further below (section 6). There are two SAPs, NELSAP (The Nile Equatorial Lakes Subsidiary Action Program) involving the six countries in the south sharing the White Nile plus the two downstream countries, and ENSAP (The Eastern Nile Subsidiary Action Program), involving Ethiopia, Sudan and Egypt on the Eastern Nile. The Eastern Nile Technical Regional Office (ENTRO), based in Addis Ababa, is also in charge of managing and coordinating ENSAP. ENSAP consists of nine projects, one of which, the Eastern Nile Watershed Management Project, is discussed further in section 6. An important outcome of this process is that the eastern Nile countries have agreed on and initiated joint hydro-electric investment projects that will bring mutual benefits to the three countries. Further information is available at www.nilebasin.org and is summarized in Mohamed & Loulseged (2008).

The NBI provides a broad institutional context for addressing the CPWF Basin Development Challenge with a focus on Ethiopia: what happens in the Ethiopian Highlands is critical to the future development of Sudan and Egypt as well as Ethiopia. The basic premise is that if the current vicious cycle of low productivity of land and water, poverty, and degradation of natural resources can be reversed into a virtuous cycle of rising productivity, improving human well-being, and reversing land

forest and water degradation, not only will the people of Ethiopia benefit, but the inhabitants of the downstream countries will benefit as well. This provides a strong justification for the CPWF focusing its Nile investments in the highlands of the Abay Basin.

4. Evolution of the Policy and Institutional Framework for Rainwater Management

4.1 Institutions

Government at federal, regional and local levels[12]

During the *Derg* period, 1975-1991, the government of Ethiopia was highly centralized and authoritarian. It had nationalized all land and most major industries; private ownership of land was made impossible. There were numerous ministries and ministerial-level "commissions" at the national level, some with overlapping responsibilities (for example relative to rural development; see FAO 1986a:47). Ministries and commissions reported to the Council of Ministers, which in turn liaised with the National Revolutionary Development Council and the Office of the National Committee of Central Planning, while reporting to the General Assembly under the Chairman, i.e., the Head of State. Because of the predominantly rural nature of Ethiopia, most of the ministries and commissions were concerned directly or indirectly with rural development. For purposes of administration, Ethiopia was divided into 14 Regions, each subdivided into *Awraja*s or zones (102 in all). *Awrajas* were further subdivided into *woredas* (equivalent to 'district'; alternative spelling *wereda*); under these but not reporting directly to them were Peasant Associations (PAs), which also had certain governmental and administrative functions – especially with regard to land distribution and its administration. As of 1984, there were some 19,579 Peasant Associations in existence (of which 90% were in the Highlands), with a total membership of some 6.67 million farm families. PAs, according to FAO (1986a:62) were "the basic social, economic and developmental unit in the rural Highlands and in practice the administrative and law and order units in their specified areas. They were the most prominent social institutions in rural Ethiopia, especially as vehicles for the participation and mobilization of rural people in their economic, social and political development and for the defense of their rights."

After 1991 the new government committed itself to a de-centralized political system, enshrined in the Constitution of the Federal Democratic Republic of Ethiopia ratified in December 1995. The new state comprises nine largely ethnically based regional states and two autonomous administrations. The regional states have substantial legislative, executive and judicial powers and responsibilities, especially for preparing and implementing development plans and providing basic social services. The regional states have strong mandates for land and water management except for waters shared by two or more states or international waters, which come under federal control. Other powers retained by the federal government can be delegated, as for example land administration has been.

The administration of rights to land has been a core issue facing the government. It retained the previous government's legal position against private ownership of land; but in principle every citizen has a right to land for farming, including its transfer to children as inheritors and the ability to lease

[12] The post-1991 paragraphs in this section are largely based on Amede et al 2009; Haileslassie et al 2008; & Hagos et al 2009. Hagos et al 2009 is especially useful on this topic.

land to a third party. This policy is contentious: there are many who argue for a return to private land ownership. Under the *Derg*, land was periodically redistributed to ensure a balance between family size and needs and land allocations; this continued in the early years of the present government. Land distribution, or its threat, has also been an important mechanism for political control (Crewett et al 2008[13]). Uncertainty about land tenure security has been blamed for farmers' reluctance to invest in improved water and land management (though some studies discount this; see e.g., Beshah 2003). However, recent programs in all the major regions to promote mapping and certification of land use rights appear to be having important positive impacts. In a 5-year period over 20 million parcels have been registered by six million households at a cost of about $1/parcel (Haile et al 2005; Haileslassie et al 2008; Deininger et al 2008a, b).

At the federal level, the key organizations related to AWM are the Ministry of Agriculture and Rural Development (MoARD), Ministry of Water Resources (MoWR), and the Environmental Protection Authority (EPA). The Ministry of Agriculture (MoA) was replaced by MoARD in 2001, consolidating what were two separate ministries. Its mandate was specified clearly in a 2005 Proclamation as follows: "to develop and implement a strategy for food security, rural development, and natural resources protection; support development of local (through expansion of cooperatives and the provision of credit facilities) and export markets; development of rural infrastructure and promotion of improved rural technologies and disaster prevention and agricultural research" (Hagos et al 2009: 195). Since 2005 this Ministry has been responsible for promoting small-scale irrigation. It is also responsible for SLM and RWM, now through its SLM Secretariat.

The MoWR was established in 1995 to promote the development, management and use of water resources. Previously water resources development had been under a Commission (1971-1975) and then an Authority under the Ministry of Mines and Water Resources. The duties of the MoWR include carrying out basin studies to identify the surface and groundwater potential, undertake studies and negotiate treaties for use of international waters, and design and construct medium to large scale irrigation dams. It also oversees the National Meteorological Agency (NMA). Before 2005 the MoWR had been responsible for small-scale as well as large-scale irrigation. It is also involved in integrated watershed management in cooperation with MoARD, especially for protection of the watersheds of its dams (for example in the Tana Beles and Koga Irrigation Projects). The EPA is a regulatory authority responsible for nation-wide environmental protection.

At regional level, the respective Bureaus of Agriculture and Rural Development (BoARD) are mandated by the Constitution to promote agricultural development; bureaus of water resources have a parallel mandate for water. Although they can and do devise their own policies and procedures, in fact they are largely the executing agencies for MoARD at regional level. Hagos et al (2009: 197) states that their roles and responsibilities related to land and water management include: developing laws on the conservation and utilization of forest and wildlife resources; coordinating food security programs; providing agricultural extension services and support for water harvesting and irrigation development activities; and promoting market-led agriculture development and creating efficient agricultural input and product marketing systems. The latter includes organizing cooperatives, but unlike the federal ministry, conservation of soil and water resources is

[13] Crewett et al (2008) is an especially important paper, explaining the complexities and variations in land tenure arrangements from the imperial period to the present, using a "bundle of rights" perspective.

not mentioned as one of the prime responsibilities of regional bureaus. At w*oreda* (district) level, Agricultural and Rural Development Offices (ARDOs) play a similar implementation function.

The regional Environmental Protection and Land Administration and Land Use Authorities (EPLAUAs) combine the responsibilities of EPA regarding environmental protection, and responsibility for land administration; importantly EPLAUAs have specific responsibilities to develop policies and guidelines for soil and water conservation. The Regional Bureaus of Water Resources Development (BoWRD) similarly manage water resources on behalf of the MoWR, while *Woreda* Water Desks are responsible for planning, budgeting and implementing water projects. The BoARDs and ARDOs are the key government implementing agencies for RWM-integrated watershed management-SLM programs in their respective jurisdictions. *Woredas* are governed by a Council, to which a 'Desk for Rural Development' reports. It is this Desk that oversees the *Woreda* agricultural and rural development office and water desk – not the federal ministries. Sub-districts (*kebele* in Amhara, *tabiya* in Tigray) have a similar formal structure with a council, cabinet, and various committees (see Box 2).

Box 2: A Note on Local Administration

The *kebele* is the smallest administrative unit of Ethiopia, similar to a 'ward'. It is also referred to as a "Peasant Association" (PA) since the *Derg* created them in 1975 to promote development and manage land reform. They have been retained by the current government for providing basic services and maintaining political control. A *kebele* usually consists of several villages (*got*). Several *kebele* constitute a *woreda*, which since 2002 have acquired considerable authority including staff and budgets. *Woredas* are in turn grouped into zones which form Regional National States (*kilil*). Zones are recognized areas, often used as reference locations in development literature (hence, "South Wollo," "North Gojam," etc.) but are less important politically and in terms of implementing development programs than regions, *woreda*s and *kebeles*.

Currently Ethiopia has no legally constituted basin management authority for the Eastern Nile river basins, though there are ongoing discussions and planning processes (and a directorate in the MoWR). The Tana and Beles Integrated Water Resources Development Project (TBIWRDP) specifically states that a major component of the project will be implemented through the Abbay River Basin Organization (ARBO), the Tana Sub-basin Organization, and the Beles Sub-basin Organization (World Bank 2008d:14), but these have yet been established[14]. There are also no formal institutional arrangements for watershed management, though various NGOs and donor-funded projects have established informal watershed management associations at micro-watershed level.

Parallel to the Ethiopian Institute of Agricultural Research (EIAR)[15], an autonomous body within the MoARD responsible for national agricultural research, each regional state has set up its own agricultural research institution (for example Amhara Regional Agricultural Research Institute, ARARI), supported technically by EIAR. Several donor-funded projects have attempted to establish more effective links between the regional research institutions and agricultural extension, for

[14] An authority for the Awash River Basin has been established.
[15] Until recently, this was called the Ethiopian Agricultural Research Organization (EARO).

example USAID's Amhara Microenterprise Development, Agricultural Research, Extension and Watershed Management Project (AMAREW; see Gebrekidan et al 2007).

Improving extension services has been a high priority for the present government (and indeed the previous one as well). Two recent studies document the evolution and performance of extension services (Mogues et al 2009; IFPRI & McKinsey & Company 2009). In the 1990s, the government pushed a set of standardized extension packages, with quotas established from the top, with mixed results. More recently, under the "Participatory Demonstration and Training Extension System" (PADETES[16]) and the subsequent "National Agricultural Extension Intervention Program," government has de-centralized extension services, training thousands of new specialists ("Development Agents," DAs). In the four largest regions, the government has tried to base teams of three specialists in each *kebele* (for crops, livestock and NRM, and there are plans to include one specialist in irrigation in *kebeles* where irrigation is important); though Zeleke et al (2006) note that each DA tends to work as a generalist, not making use of his or her specialization. It is also currently establishing Farmer Training Centers (FTCs) in every *kebele*[17]. The DA team deploys on a watershed basis, and is the front line implementing agency for SLM and RWM programs. DAs are trained at Agricultural Technical and Vocational Education and Training Schools (ATVETS). These schools have already produced nearly 60,000 graduates. DAs still tend to promote standardized packages, though they may have become less rigid and sometimes offer a menu of choices now[18]. Based on a survey of 1477 households in 15 villages, Dercon et al (2008) find that at least one visit from an extension officer significantly reduces headcount poverty. The IFPRI and McKinsey team (2009) makes substantial recommendations for strengthening the capacity of the extension system to deliver; while Mogues et al (2009) report on the perspectives and views of farmers, with an emphasis on improving the access of women farmers to extension services. Spielman et al (2010) are more critical in their evaluation of the impacts of extension services, pointing out there is little evidence of sustainable uptake of fertilizer and improved seeds or of improved yields. They advocate radical reform including opening up to more private sector provision of inputs and extension services.

In conclusion, it is clear that a radical institutional re-orientation is underway, from top-down command and control quota-driven programs to a more decentralized and ultimately demand-driven system – though there is still a long way to go. The combination of an authoritarian history with the mind-sets this creates among both officials and farmers, and a government that is vigorously promoting rapid development – sometimes with understandable urgency and impatience – means that creating such a de-centralized demand-driven system will take time. A continuing characteristic of this reform process is constant re-organization of implementation structures – a process that is cited by many sources as a major impediment to progress; this is documented further below. And top-down blueprint approaches to rural development remain pervasive with agricultural extension still largely focused on technology transfer (Segers et al 2008; Spielman et al 2010).

[16] This is an integrated program of extension, seed, fertilizer and credit that was initially piloted by Sasakawa-Global 2000 (SG 2000) (Spielman et al 2010).

[17] There are currently about 62,000 DAs and 18,000 FTCs (T Amede, personal communication).

[18] Teshome (2003: chapter 7) provides a detail analysis of the working of PADETES in a community in Tigray in 2001, describing it as "coerced persuasion."

Local level institutions

The role of local government, *kebele*, has been discussed above. In addition, there are numerous formal and informal institutions and organizations at local level, whose roles and effectiveness exhibit considerable variation. There is remarkably little information in the literature on local institutional arrangements[19]. This section therefore highlights only a few of the most salient. An important non-government institution is the church (and mosque in Muslim communities). The Orthodox Church plays a central role in the lives of rural people, economic as well as social and spiritual. For example, in many highland communities the only indigenous forests remaining are those managed by the church. Pankurst (2001) says religious leaders play important roles in resolving interpersonal disputes, and rituals at the first plowing. The Ethiopian Orthodox Church through its development arm is also actively involved in education and health services in the highlands as well in the provision of clean water and conservation of natural resources. The *Kire* (or *Qire* or *Qero*) is a village-based institution in which all family heads are members. It is a mutual aid society, especially for organizing burials and even weddings. It mediates disputes and can enforce decisions through sanctions; ostracism is its most important sanction (Pankhurst 2001; Beshah 2003). The *Sheni* (group of elders) often also settles disputes.

As noted above in the discussion of land degradation, a great deal of land in the Highlands is common property, managed by the *kebele* or by the village community (and 'private' land converts to common land for grazing during the dry season). Effective collective action for managing woodlots, grazing land, and more generally the catchment areas of water bodies is therefore a critical requirement for reversing degradation and ensuring people benefit from them. Gebremedhin et al (2006) found from a study in Tigray that community woodlots and grazing lands were common (9 out of 10 sample districts). All restricted grazing lands (which are long-established) were managed at village level, while woodlots (established more recently, usually with government or NGO support) were managed at both levels. Violations of rules about use and exploitation were more common in district-managed than in village-managed woodlots. Overall, reported benefits were greater and management problems fewer on village-managed woodlots. The same study found an inverted U-shaped relationship between population density and collective action for both woodlots and grazing lands: "collective action is higher and more effective at intermediate population density or level" (Gebremedhin et al 2006:272). In a study of two sites each in Ethiopia and Uganda, German et al (2008) found that local institutions were abundant everywhere; they included local savings and loan rotational savings groups, religious associations, funeral associations and stretcher groups, labor sharing arrangements for private and communal works, traditional conflict resolution mechanisms, saving or pooling resources for celebrations, commercial labor groups, and land and livestock sharing arrangements. However, they also found that local collective action groups were not effective in managing natural resources, for example SWC technologies, and needed support and assistance. Collective management of common property resources is discussed further in section 7, below.

Other common property resources managed collectively include small-scale irrigation (SSI) schemes. Traditional (i.e., farmer-built and managed) SSI have their own management arrangements, for

[19] Ashkenafi & Leader-Williams (2005) is one of the few exceptions; it discusses the evolution of a common property resource management system into the present in the Central Highlands. Another is Pankhurst 2001, who discusses local dispute resolution processes and how they have evolved over the past century; see also Tesfay 2006: chapter 6.

example through a "water master." On both "modern" (newly constructed with government assistance) and improved traditional schemes, under donor pressure, authorities encourage the creation of "water users associations" (WUAs) and irrigation cooperatives. WUAs have no legal status, and therefore not all irrigators become members. Irrigation cooperatives are promoted by the *Woreda* Cooperative Promotion Office, but an IFAD evaluation team found not all irrigators are members. Sometimes all three exist simultaneously. Government is not building on the indigenous arrangements effectively, but the introduced organizations are also not effective (IFAD 2005; Adgo et al no date). Other studies have reported that misunderstandings, ineffective communication and lack of empowered participation characterize the development of SSIs (e.g., Teshome 2003, 2006; Wegerich et al 2008)[20].

Since 1994, the government has been promoting cooperatives as a mechanism for commercializing agriculture (for both outputs and inputs). These are in principle designed to be inclusive in terms of membership, governance and provision of services. Despite the efforts of government, by 2005 only 9% of households had become members of a cooperative; and most of these members were "middle class" in terms of their assets and characteristics. Poorer farmers tend not to participate though they may benefit indirectly in any case; and when they do participate they are often excluded from decision-making. Surprisingly, the same study found there are trade-offs between marketing performance and inclusiveness (Bernard & Spielman 2009).

Major development partners

As demonstrated by the list in Annex Tables 6 and 7, Ethiopia has a large number of bilateral and multilateral development partners. Many though not all support rural natural resource management programs, i.e., water resources and irrigation development and soil and water conservation, and most are supporting programs in the Eastern Nile including the Abay Basin. All of their programs are broadly aligned with the Government's "Plan for Accelerated and Sustained Development to End Poverty" (PASDEP; see below). Both the World Bank and African Development Bank are major investors in irrigation (large and small scale), integrated watershed management, and sustainable land management – i.e., rainwater management – in the Abay Basin. Among UN agencies, IFAD has remained a major investor in SSI and SWC for decades; the World Food Program is a major investor in IWM through its long-standing support of the MERET project, "Managing Environmental Resources to Enable Transitions", discussed below, in partnership with MoARD, while FAO also has been working on SLM for decades. The major bilateral donors investing in RWM include: the European Commission, Germany (GTZ), United States (USAID), Sweden (SIDA), Canada (CIDA), United Kingdom (DfID), Netherlands, Irish Aid, Japan (JICA), and Austria. Most of these development partners have traditionally worked through specific projects, with their own goals and implementation arrangements. In some cases these have supported important experimentation and innovations that have been scaled up subsequently; but in others the post-project sustainability of these investments has been an issue. In recent years, development partners have aligned more closely with government programs, providing support based on a broad agreed program. The new SLM Program with its Secretariat in MoARD is an example of this approach.

[20] Nevertheless, recent studies have documented significant reduction in poverty among beneficiaries of irrigation; examples include Tesfaye et al 2008; Gebregzhiaber et al 2009; Hagos et al 2009; Hanjra et al 2009b; Bacha et al 2010.

Major nongovernment and international research organizations

Annex Tables 6 and 7 also list the major implementation NGOs and international research organizations working on RWM in Ethiopia. The list of NGOs is incomplete but still long. IFAD (2005) notes that NGOs including Lutheran World Federation, World Vision, SOS Sahel and Mekhane Yesus are active in SSI and rural development. During this study we found only a few international NGOs working directly on RWM, though some work on related areas such as agricultural marketing and water supply and sanitation. Examples of international NGOs said to be working on RWM include CARE/E, World Vision/E, CRS/E, IDE, FARM-Africa, Sasakawa Global 2000, Oxfam/UK, SNV, Water Action, A Glimmer of Hope Foundation, SOS-Sahel, and GOAL. It is remarkable that these international NGOs rarely publish external reviews of the outcomes and effectiveness of their programs. There are also several important indigenous NGOs working on RWM including: the Organization for Rehabilitation & Development of Amhara (ORDA), Relief Society of Tigray (REST), Amhara Development Association (ADA), Tigray Development Association (TDA), Christian Relief & Development Association (CRDA), Ethiopian Orthodox Church Development and Inter-Church Aid Commission, Team Today and Tomorrow (TTT), Agri-Service Ethiopia, Prolinnova-Ethiopia (also known as PROFIEET, Promoting Farmer Innovation and Experimentation in Ethiopia), Sustainable Land Use Forum (SLUF), Support for Sustainable Development (SSD), and Ethiopian Wetlands and Natural Resource Association (EWNRA)[21]. ORDA and REST are government-sponsored NGOs. They often work with international NGO partners; for example ORDA works closely with Canadian Hunger Foundation, Save the Children/UK, Care/E, and German Agro Action (DN-Consult 2007).

With the exception of ORDA and REST, again there are few available external assessments of program outcomes. The exception is a set of five case studies from SLUF (2008a, b). Agri-Service Ethiopia has been implementing a "community empowerment approach" in a *woreda* in Amhara State. The community based institutions have organized people for improved SWC both on farms and on common areas, and for effectively managing the common areas through restricted grazing (SLUF 2008a). EWNRA has implemented a successful integrated catchment and wetland management program in a wet mid-altitude area (*Weina Dega*) of Oromiya, while Water Action has facilitated a successful community-led participatory land planning process in an Amhara Region watershed (SLUF 2008b).

There are also a number of important international agricultural and natural resources management research organizations with substantial RWM-related programs in Ethiopia. These include many of the CGIAR centers (especially ILRI, IWMI, IFPRI, ICRISAT, ICARDA, CIMMYT), Overseas Development Institute (ODI), the Eastern Nile Technical Regional Office (ENTRO), and the Organization for Social Science Research in Eastern and Southern Africa (OSSREA). In addition, internationally recognized universities work on SLM issues in Ethiopia in partnership with local universities and research institutions as well as CGIAR centers; these include Cornell University (USA), University of Berne (Switzerland), Catholic University (Belgium), and Wageningen University (Netherlands). There are also important – and increasingly effective – Ethiopian research institutions and think tanks, who often partner with international universities and CGIAR centers. These include the: Ethiopian Development Research Institute (EDRI), Environmental Economics Policy Forum for Ethiopia (EEPFE), Forum for Social Sciences (FSS), and Institute of Development Research (IDR). These are

[21] It is likely there are many others; SLUF (2008a) refers to a report stating there were over 900 NGOs operating in Ethiopia in 2006.

complemented by Ethiopian universities combining research and education: Addis Ababa, Arba Minch, Hawassa, Bahir Dar, Ambo, Haromaya, Mekelle and Jimma.

Conclusion: Institutional gaps and overlaps

Ethiopia's efforts to improve the management of its natural resources as a basis for improving agricultural productivity has strong support from committed development partners and international as well as local NGOs, research institutions and universities. The government has been investing substantially in strengthening capacity through both human resources development and encouraging a decentralized, demand-driven governmental structure. Progress has been exemplary. Nevertheless, quite a number of institutional problems and weaknesses continue to characterize the system, reducing its performance. These are often noted in both program evaluations and by researchers (e.g., Zeleke et al 2006; Hagos et al 2009). Briefly the list includes overlaps in mandates; poor inter-sectoral and inter-departmental communication and coordination; lack of clarity and even some conflict regarding lead responsibilities (e.g., between federal, regional and *woreda* levels); ineffective enforcement of regulations; lack of systematic monitoring and evaluation systems; continuing *de facto* reliance on command and control from the top; and constant disruptive re-organizations (the latter is a frequent complaint, voiced even in 1986 [FAO 1986a]). There is also a failure to build more effectively on indigenous informal institutions. It is nearly impossible to implement IWRM effectively because of the lack of basin-level institutional arrangements and the lack of fit between hydrological and administrative boundaries (even on some small watersheds). These continuing issues – many not unique to Ethiopia – continue to have important impacts on implementation of policies and programs.

4.2 Policies and strategies

As has been the case for institutional arrangements, agricultural, rural development and natural resources policies show some continuity from the past as well as major differences. For example the radical land reforms were retained but are being refined in the context of a market-oriented economy; and since 1991, agricultural and rural development remains the highest policy priority of government, through its "Agricultural Development Led Industrialization Strategy" (ADLI). This section briefly and selectively characterizes the current policies most relevant to RWM, and then reviews selected studies on their effectiveness.

Agriculture, rural development, water resources and environment policies and strategies

ADLI remains the core of government policy though the strategies for its achievement have evolved. It seeks to use agricultural development as the main engine of growth and provides a broad framework for other strategies. Although officially all the major stakeholders accept ADLI as the main policy framework, behind the scenes questions are being asked; for example does it pay sufficient attention to the demand side, urbanization which is occurring rapidly in the country, and marketing? Another long-enduring priority is contained in the National Food Security Strategy, whose central objective is to ensure food security at the household level within the ADLI framework. Its target areas are the chronically food insecure moisture-deficit areas and pastoral areas. Since 1996 it has provided a strong basis for investments to reverse environmental degradation including promotion of water harvesting technologies and high value crop production (Amede et al 2009a). It also provided the basis for the Food Security Program of the "New Coalition for Food Security in Ethiopia," a coordinated government and development partner program to improve food security of 3 million households of which 1 million were to graduate to food secure status (2004-2009).

However, the really critical policy statements over the past decade have been the two five-year poverty reduction strategy programs. From 2000-2005, the Sustainable Development and Poverty Reduction Program (SDPRP) was the governing document (MoFED 2002). Built on ADLI, it focused on promoting rapid overall development, liberation from dependency, promotion of a market economy, and deepened de-centralization; and among others, it introduced more extension packages, micro-finance programs, autonomous cooperatives, and development of better marketing infrastructure. The Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) replaced SDPRP for the period 2005-2010, and is referenced by nearly every proposed investment program (MoFED 2006a, 2006b). Built on SDPRP and ADLI, PASDEP placed more emphasis on enhancing the private initiative of farmers and supporting diversification and commercialization of agriculture while also improving pro-poor agriculture, local support services and SSI. PASDEP (like SDPRP) distinguished three main economic and agro-climatic zones: the traditional semi-arid/sub-humid highlands; potentially productive semi-tropical valley areas; and hot semi-arid lowlands (often referred to as the "three Ethiopias"; see section 8.2 below). Importantly, it emphasized the importance of community-based approaches to watershed management and reversing land degradation. It was budgeted at ETB 332.56 billion overall, of which ETB22b was for agriculture, rural development, and food security, and ETB 20.75b was for irrigation. The Ministry of Finance and Economic Development (MoFED) periodically issues reports on progress in achieving the PASDEP and Millennium Development Goals (e.g., MoFED 2007, 2008a, 2008b), which demonstrate substantial progress overall. Debela et al (2004a, 2004b) is a detailed report attempting to quantify the needed interventions and investment costs to achieve the Millennium Development Goals (MDGs) 1 and 7 on poverty and hunger reduction. The intervention packages are NRM and rural infrastructure; agricultural production, agricultural marketing, and access to food. In September 2010, the government announced its new "Five Year Growth and Transformation Plan," an ambitious program covering 2010-2015 whose overall goal is to achieve 'middle income' status by 2020, with investments in agricultural development continuing as a major driver[22].

The Ministry of Water Resources (MoWR) produced in rapid succession its "Ethiopian Water Sector Policy," "Water Sector Strategy," and "Water Sector Development Program" (WSDP) (MoWR 2001a, 2001b, 2002). The Policy sets out broad goals, objectives, principles, strategies, and priorities. The overall goal of the policy is to "enhance and promote all national efforts towards the efficient, equitable and optimum utilization of the available Water Resources of Ethiopia for significant socioeconomic development on a sustainable basis". The policy is largely focused on developing blue water. The sector strategy proposes short, medium and long-term action programs to achieve the policy goals; i.e., it provides a road map for development and management of water resources and lists specific actions and development projects and programs to be developed and implemented. Its major elements include: providing clean potable water access to all of the population over the coming seven years; promoting enhanced irrigation development in an integrated manner to contribute to economic growth and alleviation of poverty and food insecurity; promoting multipurpose development of water resources wherever applicable; building capacity at different levels, particularly at sub-national level where actual implementation is taking place; focusing on low-cost, affordable, and labor-intensive technologies; and improving sanitation outcomes. The WSDP provides detailed technical plans and guidelines for all planned activities, identifies the major

[22] Because this was announced after this paper was completed, and we have not seen the actual document, we have not been able to include an analysis of the new plan here.

outputs, and proposes investment plans for each major sub-sector over the policy period of 2002-2016. The total budget estimate is $655.6m. As Hagos et al (2009) note, these policy documents are entirely focused on "blue" water, i.e., surface and groundwater. Ethiopia has no policy on "green water," i.e., RWM as defined by the CPWF.

There are other important policy and strategy documents governing RWM programs. These include the Environmental Policy and accompanying Conservation Strategy of Ethiopia, dating from 1997 and implemented through EPA. Their overall goal is to enhance the health and quality of life of all Ethiopians and promote sustainable social and economic development through sound management and use of natural, human-made and cultural resources and the environment as a whole (Debela et al 2004a; Amede et al 2009a; Hydrosult 2006); the Ethiopian Forestry Action Plan (EFAP; 1994-2014); National Action Plan (NAP) to Control Desertification (2007-2012); the Livestock Development and Conservation Policy and Strategy; and the Climate Change National Adaptation Program of Action (NAPA) of Ethiopia, whose time frame is not specified. It recognizes the importance of integrated NRM as an adaptation to climate change and lists "community-based rehabilitation of degraded ecosystems" as one of 20 high priority projects (NMA 2007; Bewket 2009). As Debela et al (2004a: 58) note, SWC is perceived in the context of the conservation strategy.[23] This study attempts to estimate the total cost of improving SWC on 10.6 million ha of cultivated and 17.1 m ha of uncultivated land, about 5.8 m water harvesting ponds, dug wells and/or springs, and 54 m each of low-cost lifting and low-cost drip irrigation kits among other targets (Debela et al. 2004a: 65-71; 2004b)[24].

Finally, a very important and more recent document is the Ethiopian Strategic Investment Framework (ESIF) for Sustainable Land Management (SLM) referred to as the "National SLM Framework" (MoARD-SLM Secretariat 2008; ANRS, GEF & IFAD 2008; World Bank 2008a). This is a framework to guide SLM planning and investments to address the linkages of poverty and land degradation. It was apparently developed with support from TerrAffica (www.terrafrica.org), under Pillar 1 of CAADP (see FAO 2009), and also draws on the World Bank's SLM sourcebook (World Bank 2006b). Its development objective is to improve livelihoods and economic well-being of farmers, herders, and forest users by scaling up SLM, while its environment objective is to rebuild natural capital assets. It has six component areas: 1) field-based projects (the largest component); 2) land tenure administration; 3) capacity-building; 4) improving the policy, legal, institutional, and financial environment; 5) building the SLM knowledge base; and 6) management & implementation of ESIF. ESIF is to be implemented in three phases from 2009 to 2023. It is being implemented by MoARD and the National SLM Platform supported by multiple donors; there is a National SLM Steering Committee and a National SLM Technical Committee. The national structure is replicated at regional levels. It is budgeted at $6.7 billion over 15 years through a variety of ongoing and planned projects. This important program is discussed further below, in section 5.1.

The National SLM Framework demonstrates a shift from conservation as the primary goal, to improving livelihoods *through* SLM – an important development in the evolution of land management policy. The CPWF's RWM program is consistent with these various policies, and is especially supportive of the National SLM Framework. To maximize the potential impact of the

[23] There is evidence this has been part of the problem in scaling out SWC; until recently it was not linked to farmers' immediate need to improve their productivity and incomes; see section 7, below.
[24] One assumes Debela et al (2004a, b) was prepared as an input to PASDEP.

program, it will be critical for the CPWF researchers to establish close working relations with the national and regional SLM secretariats, steering and technical committees.

Review of selected agricultural policy studies

There is a very large literature analyzing the effectiveness and outcomes of Ethiopia's agriculture, rural development and natural resources policies. Some of the studies on policy impacts at local levels are reviewed below. This section briefly reviews a few studies on the overall effectiveness of Ethiopia's agricultural and land administration policies as these establish the context of the work on RWM.

No studies question the basic thrust of Ethiopian policy, i.e., investing in agricultural and rural development as the means to promote growth and reduce poverty – this has become the "received wisdom" for African development, promoted under CAADP. Rather, most studies examine how these investments can be more effective. For example, Dorosh & Thurlow (2009), using a new 'computable general equilibrium' model, argue that Ethiopia can meet and sustain its current 6% agricultural growth target[25] and this will indeed substantially reduce poverty by 2015. However, they argue that the largest impact on poverty gains will be achieved by additional growth in cereals as these constitute a large share of rural incomes as well as consumption by the poor. Mellor & Dorosh (2010) build on this to argue that achieving high levels of agricultural growth can best be achieved by a combination of rural infrastructure investments (roads, electricity, telecommunications) to reduce marketing costs and enable growth in rural marketing towns, accelerating growth in seed and fertilizer production and distribution, and engaging more effectively with "middle farmers" – those large enough to adopt new technologies and produce large surpluses. They argue this would provide enough employment growth to bring rapid transformation of the economy and poverty reduction. Spielman et al (2010) argue that the current state-led policies for promoting agricultural growth have "now outlived their usefulness" and should be replaced with policies aimed at strengthening the market economy and private sector participation in input markets and extension. These views are supported by the findings of Mogues et al (2008), who assess the "bang for the birr" from different public investments. They find returns to investments in roads are by far the highest (but with high geographical variability) while the household welfare impacts of direct public investments in agriculture are modest and statistically insignificant. They argue for more research on the efficiency with which public resources are used, especially agricultural investments. How effective SLM and RWM investments are will be addressed further below – the results of many studies taken together are decidedly mixed.

5. Evolution and Outcomes of Major Rainwater Management Development Programs: From Coerced to 'Incentivized' Participation

Projects addressing soil degradation and improved RWM began proliferating from the late 1970s and continue to date. They range from small localized NGO projects, on which we found little information, to major national government programs, mostly co-supported by development partners and government. This section analyzes the experiences and lessons learned from selected projects and programs whose main purpose has been developmental, in contrast with the research

[25] The target is now far higher for 2010-2020.

projects reviewed in section 6. A complete discussion of individual projects would constitute a separate report[26]. Therefore, after briefly describing a few key past and present projects and programs, we synthesize the trends and lessons learned as documented by project completion and evaluation documents as well as researchers.

5.1 Historical overview of selected RWM projects

The longest-running SWC program in Ethiopia is MERET, "Managing Environmental Resources to Enable Transitions." This program is a joint venture of the MoARD and the World Food Program (WFP), and its early phases were driven by the urgent need to provide food assistance. Its exact origins are not clear; officially it began as "WFP Project ETH 2488 – Rehabilitation of Forest, Grazing and Agricultural Land" in 1980 but some efforts began earlier than this project[27]. The Project combined provision of food aid to chronically food-insecure rural people with construction of SWC infrastructure in degraded areas, mostly in "low-potential" (i.e., drought-prone) regions. It therefore used Food for Work (FfW) as its main implementing strategy, a strategy that continues to date. This phase was very top-down, using "command and control" and coercion, with little systematic planning or local participation in decision-making. The selection of sites and SWC technologies was done by technicians with no community consent (Nedessa et al 2005). There was therefore no community ownership of the infrastructure since the works were motivated entirely by food. At the end of the *Derg*, many (though certainly not all) of these assets were destroyed. However, some 2.3 million people did receive food (Bewket 2009; Cohen et al 2008, Zeleke 2005). From 1987 to 2002, MERET went through three more phases[28], with a gradual shift in implementation strategy. MERET became more community-driven, adopting and over the years refining its Local Level Participatory Planning Approach (LLPPA), focusing on small rather than large watersheds, and targeting more systematically using "Vulnerability Analysis and Mapping" (VAM). It also changed its emphasis from a technical focus to capacity building and income generation ("food for assets"). Assessments of these phases are far more positive, claiming there is evidence of increasing empowerment and benefits for women, significant improvements in food security as a result of higher production, some income generation and asset creation among beneficiaries, and increased capacity of regional and local technicians as well as beneficiaries (Nedassa 2003; Cohen et al 2008; Zeleke 2005; Bewket 2009; Fanzo & Pronyk no date; Amede et al 2007)[29]. A very important achievement was the production and dissemination of the "Community Based Participatory Watershed Development" (CBPWD) guidelines (Lakew Desta et al eds, 2005a, b), based on the evolved versions of LLPA. This is now the standard handbook and training manual for IWM programs in Ethiopia (see Box 3, below). An important lesson that has informed other programs is that the main objective of IWM should not

[26] FAO 1986b:336ff contains a detailed list of ongoing projects at that time; EPA 2004: Annex III contains a very detailed list as of 2004; and the Global Facility for Disaster Reduction and Recovery (www.gfdrr.org) also contains a fairly comprehensive list for Ethiopia.

[27] Nedassa (2002) says the first FfW activity began in 1972 in Wello supported by USAID; WFP-assisted FfW was initiated in 1974.

[28] The name "MERET" was coined for the project beginning in 2002; see Zeleke 2005.

[29] Actual figures vary as each source refers to different time periods; but Bewket (2009) says as of 2008 MERET had covered over 600 sub-watersheds each with 300-2000 participating households in 74 *woredas* in six regions, and rehabilitated over 400,000 ha of degraded lands. It has directly benefited over 1.3m people. Bewket quotes a cost-benefit analysis by WFP in 2004 of 13.5% over the previous 25 years. See also Zeleke 2005.

be reducing soil loss, but rather enhancement of rural livelihoods through sustainable land (and water) management (Zeleke 2005; Lakew Desta et al eds, 2005a, b).

MERET Plus ("MERET through Partnerships and Land Users Solidarity") is the current and likely last version of MERET (2007-2011). WFP (2006) says the target is to benefit 1.7 million people over five years in 65 *woredas,* and improve 125,000 ha. It is similar to previous MERET programs, but with more emphasis on community capacity building, homestead production and income generation; it remains focused on lower potential areas mostly in Tigray, Amhara, SNNPR and Oromiya (though the government proposes to shift its priority to high potential areas in future). Its packages are much-expanded to include not only physical and biological SWC technologies, but also soil fertility management, agro forestry and forestry, income generation, homestead gardens and crop diversification, RWH and SSI (in the form of small household ponds, shallow wells, spring regeneration, etc.) (EDRI & World Bank 2006; WFP 2006; Cohen et al 2008; Bewket 2009; IASC 2009; Yirga 2010; AH Consulting 2010; MoARD 2010). The key elements of success are flexibility and experiential learning, community ownership, gender sensitivity, central focus on livelihood improvement and its integration with land management, provision of income-generating opportunities, alignment of the project with government programs and policies, and a focus on small watersheds over a sufficiently long time frame to achieve results (Bewket 2009; IASC 2010). The influence of MERET on other programs is discussed further below.

Parallel to MERET, there have been many bilateral programs supporting SWC-RWH-SSI interventions in specific Regions (especially Amhara and Tigray). These include the SIDA/ANRS Rural Development Project (SARDP), implemented in several phases from 1998 to 2010 in Amhara; the USAID-supported Amhara Microenterprise Development, Agricultural Research, Extension and Watershed Management Project in Ethiopia (AMAREW, 2002-2007); the Water Harvesting and Institutional Strengthening in Tigray Project (WHIST) supported by CIDA from 2001-2010; the BoA/GTZ Integrated Food Security Program, South Gondor (1996-2004); Norway Development Fund-supported programs with REST (Tigray, 1997-2000); and European Commission support for RWH (household ponds) in Tigray through a multi-sector program of "Comprehensive Community and Asset Building Approach," part of the 1998 and 2000 Integrated Food Security Programs[30]. SARDP was a long-running participatory rural development program in two zones of ARS with multiple dimensions that changed over time. Its aim was reduction of rural poverty through local-level capacity building; and improved natural resources management was a central thrust. AMAREW was an applied research project which, among other goals, sought to strengthen linkages among research, extension and farmers, promote new small-scale water management technologies, and develop innovative approaches to IWM in a small number of *woredas* in Amhara. For example it tested the creation and empowerment of "Community Watershed Management Organizations" (CWMOs) with positive

[30] Germany through GTZ has also been supporting important SLM programs since 1991, in addition to the Integrated Food Security Program in South Gondor (2001-2004). These have tested new technologies, for example the use of bio-physical erosion control such as vetiver grass (Wubshet 2004). Since 2005 its SLM work is consolidated under a "Sustainable Natural Resources" ("SUN") program. However, we were unable to obtain any documentation on these programs.

results (Liu et al 2008). WHIST was more focused on improving capacity for SSI, but was affected severely by the Tigray government's policy shift from SSI to household RW ponds[31].

In general, these projects struggled with weak implementation capacities and changing policy priorities as well as frequent institutional restructuring and instability of personnel. All of them focused on technical capacity building and promotion of participatory approaches. Based on the somewhat incomplete set of reports we have obtained, all of them were evaluated as having had very positive if uneven outcomes and impacts, though the evaluations also point out the lack of baseline data and inadequate monitoring and evaluation systems. All of them tried to target poor people and especially women; SARDP placed special emphasis on achieving greater gender equity. And all the evaluations expressed disappointment on these goals. While these programs undoubtedly had positive regional and local impacts, and left the regional and local authorities better able to implement participatory water and land management programs, there is little evidence they have had significant impacts on policies or subsequent programs. Exceptions may be the AMAREW and GTZ projects, acknowledged in the introduction to the CBPWD guidelines (Lakew Desta et al, eds, 2005a). Some evaluators, for example Tengnäs et al 2009 evaluating SARDP, raise concerns about the sustainability of SSI and SWC interventions. A case study of one SARDP-supported SWC project found that while farmers recognized the technical efficacy of the introduced measures, they ultimately rejected them as not fitting their needs—raising questions about the effectiveness of the "participatory" process fostered by SIDA and supporting the concerns of the external reviewers (Bewket 2007). This observation probably applies more broadly. Further, none of these projects were designed as "innovation system" projects for joint learning. Finally, Zeleke et al (2006) claim the confusion created by different donors' procedures and insistence on having their own sites "outweighs the benefits;" there are apparently instances of two or more donor projects being implemented in one *woreda*, having similar goals but very different procedures and priorities.

In contrast, MERET has clearly had major impacts on current SLM-RWM programs, especially the Productive Safety Net Program (PSNP, 2004 to present) and the SLM Program under the Ethiopian Sustainable Land Management Framework (ESIF), for 2009-2015 and beyond. PSNP is a $200 m/year program financed by multiple development partners whose objectives are to provide transfers to chronically food insecure people in chronically food insecure *woreda*s so as to prevent asset depletion at household level and create assets at the community level. It does this through public works on public or community lands using FfW and cash for work (for SWC, feeder roads, water supply, SSI, etc) and farmer training. The SWC technologies and implementation strategy are based on those developed under MERET, especially CBPWD (Lakew Desta et al, eds, 2005a, b; see Box 3).

PSNP already shows significant reductions in soil erosion and sedimentation, increased vegetation cover, increased forage for livestock, enhanced yields and base flows of springs, and increased access to safe water – all with a high benefit-cost ratio (MA Consulting & Prospect Consulting 2009; see also AH Consulting 2010 for a positive in-depth analysis of PSNP and MERET interventions in two *woredas* in Tigray). The evaluation recommends inclusion of work on private lands, arguing the lack of attention to adjacent private lands is undermining the sustainability of improved land management on public lands, and reduced soil erosion on private lands is also a public as well as

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[31] For SARDP see Simane 2002, SIDA 2005, Tengnäs et al 2009, Farnworth & Gutema 2010; for AMAREW, see Gebrekidan et al 2005, 2007; for WHIST see Ferguson & Kassa 2007; for Norway's program see Robinson et al 2001; for BoA/GTZ see ANRS BoA & GTZ 2003; for EC projects in Tigray see Landell Mills 2004.

private good. However, other studies have report more nuanced and qualified findings. Nega (2008), in a detailed assessment based on a large sample survey of participants in FfW programs in Tigray, found that the benefits were skewed toward better-off households, and there was no significant impact on chronic and transitory poverty. Segers et al (2008) report on a detailed anthropological study of both PNSP and RW ponds in one district of Tigray. They found that developers' and farmers' mutual perceptions and countermoves resulted in serious targeting errors in PSNP, and waste of resources in the RW pond program: farmers see participating in this as a stepping stone to participating in the more attractive PSNP employment and not as a beneficial investment[32].

Box 3: Community-Based Participatory Watershed Development Guideline

The Community-Based Participatory Watershed Development (CBPWD) Guideline is a detailed two-volume resource produced by the MoARD with support from several international partners (WFP, AMAREW, USAID, ILRI, and GTZ are specifically acknowledged). It builds on lessons from past experience to provide a workable and adaptable planning tool as well as guidelines on selection of technologies for different conditions and their implementation. It can be used as a text book for training or as a reference. Participatory Watershed Development Planning (PWDP) is presented as the "foundation" for sustainable agricultural development and as a means "to combat the land degradation-food insecurity-poverty nexus." It provides specific procedures for catalyzing communities to take the lead in PWDP, and interpreting the potentials of the land in view of the needs, demands and aspirations of people. Importantly, it emphasizes improving livelihoods by protecting and developing watershed resources. There is also a very strong emphasis on RWM. The Guideline provides a detailed six-step process for initiating a PWDP, assisting the community to develop and implement the plan, and subsequent participatory M&E (volume 2 provides detailed guidelines for specific tools such as participatory planning and mapping, simple surveys, and useful plant species). It also contains detailed illustrated "information kits" for a range of physical and biological SWC, RWM, soil fertility management, agro forestry and forestry, gully control, drainage and community roads technologies, including advice on the conditions for their suitability and ways to adapt them to specific situations.
Source: Lakew Desta et al eds, 2005a, b.

The newly-launched MoARD-SLM Program is intended to provide an integrated holistic framework under which government, civil society, and development partners can work together to promote and scale up SLM. It is intended to guide prioritization, planning, and implementation of SLM to more effectively address poverty, vulnerability, and land degradation, and seeks to scale up SLM practices with proven potential to restore, sustain, and enhance land productivity. The program is highly focused on sustainability (institutional, financial); emphasizes active community participation and leadership, offering a choice of technologies; and seeks quick and tangible benefits for people while avoiding perverse incentives (Zeleke et al 2006; MoARD-SLM Secretariat 2008). The World Bank and GEF have initiated the $38m five-year Sustainable Land Management Project in 35 *woredas* to support this Program. It will scale up best SLM management practices in vulnerable 'high potential/food secure' areas, on farm, homestead and community lands, and support rural land certification in an effort to enhance the incentives for sustainable land management (World Bank

[32] More recent analyses of combining agricultural and social protection goals and the need for adjusting cash for work to respond to inflation and seasonal food price variations under PSNP can be found in Devereux & Guenthe 2009 and Sabates-Wheeler & Devereux 2010.

2008a)[33]. However, it is notable that the SLM Program is not designed to encourage farmer and community innovation in partnership with extension and other personnel; it falls short of being based on an innovation system perspective. In that sense it retains elements of a supply-driven top down program, pushing presumed "best practices" onto clients with insufficient attention to their priorities and to building on indigenous practices. Further, the SLM Program does not seem to be linked to the on-going activities and interventions of projects such as PSNP, and MERET-Plus. The lessons learned from these two programs as well as AMAREW and the GTZ Food Security Program of South Gonder could also have been considered for upscaling purposes.

In addition to these programs, there are several important projects in the Abay Basin with explicit IWM components. These include the Koga Irrigation and Watershed Management Project (AfDB 2001; Hydrosult 2006); the Tana Beles Integrated Water Resources Development Project (TBIWRDP; see MoWR Abbay Basin Team 2009; World Bank 2008d); the associated Community-Based Integrated Natural Resource Management Project (CBINReMP; see ANRS, GEF & IFAD 2008; IFAD 2009a, b); and the Eastern Nile Watershed Management Project (Halcrow & Metaferia 2007 for ENTRO). The Koga Project is investing in a reservoir and 6,000 ha irrigation scheme, but is also investing in watershed management and conservation to protect the reservoir; unfortunately we were unable to obtain any recent documentation on outcomes except a critical assessment of unsatisfactory implementation of the EIA (Abebe et al 2008b)[34]. The ENTRO Project is also located in the Lake Tana watershed, but its current status is not clear. The other projects are just getting started so there are no results; however, the TBIWRDP and CBINReMP as well as the ENTRO Project are drawing explicitly on lessons from MERET and using the MoARD guidelines (Lakew Desta et al eds, 2005a, b). These projects are all active in or near the areas of the Abay Basin where the CPWF has been working and that are proposed for CPWF phase 2 field research, suggesting it would be important to establish close links to them.

5.2 Lessons learned from SLM-RWM implementation programs

Following the famines of the 1970s and 1980s, the Ethiopian government, supported by donors and NGOs, launched an ambitious environmental reclamation program using the largest Food for Work program in Africa. The early phases of MERET and other water and land management programs were characterized by top-down planning and implementation; the use of quota systems, measured in terms of km of bunds and other physical measures; lack of an integrated or systematic watershed approach; and coerced participation by an authoritarian command and control political system. On the positive side, participants did receive food rations for some though not all of their work in situations of chronic food shortages exacerbated by drought and civil unrest. However, the structures created often served no positive purpose and at the end of the *Derg* government, a large proportion of the works were deliberately destroyed or at best, abandoned. There were many other reasons for this failure: the programs included standardized packages of interventions based on inadequate scientific and technical knowledge, had little regard for the views of people or the variations in agro-ecological conditions, and were undermined by land tenure insecurity resulting from previous land reforms. Hoben (1995) presents a fascinating analysis of the "cultural

[33] The AfDB has been financing the Agricultural Sector Support Project (ASSP) which has SSI, RWH and "ecosystem management" components, but it is not clear how well it is integrated with the current SLM Program (AfDB 2003, 2008).
[34] This assessment was supported by the CPWF.

construction" of the paradigm and narrative underlying that policy, co-constructed and implemented by donors, NGOs and government.

Since the new government took over in 1991, there has been a gradual shift to more participatory community-driven approaches at the policy level and to an increasing degree at local levels[35]. Nevertheless, more recent researchers report evidence that coercion continues to occur as a means of "encouraging" participation, for example through "voluntary" contribution of labor (e.g., Bewket & Sterk 2002; Beshah 2003; Bewket 2007; Eliyas & Fantaye 2000)[36]. The widespread use of FfW and more recently cash for work raise questions about the actual motivation for participation in SLM programs: is food aid the main motivation, and if so, will this undermine community commitment to sustain the infrastructure? And is food aid creating dependency behavior among the recipients? A recent study examining the latter question in South Wollo, Amhara Regional State, finds that FfW is such an unreliable source of support that few households change their behavior in anticipation of receiving it (Little 2008). One large-scale assessment of targeting and impacts of PSNP transfers finds that in general the poorer and more vulnerable households have benefited, and are slowly improving their asset base as intended, though it also finds that many control group households are also poor and in some cases are losing assets (Devereux et al 2006). Motivation for participation in the earlier top-down programs was clearly largely for the food or because of coercion; but in more recent programs, we found no firm evidence on the impact of "incentivizing" SWC through FfW or cash for work on the motivation to sustain and improve SWC assets – this seems rather to be a function of the degree and quality of community participation. For example Holden et al (2005), while recognizing that FfW may undermine private incentives for investments, find that by linking it to conservation investments these negative side effects may be minimized, leading to win-win benefits in terms of poverty reduction and more sustainable land use. On the other hand, the lack of significant spontaneous scaling out even of technologies that are perceived positively suggests that communities continue to expect external support for such investments (Cohen et al 2008 suggest the problem is a lack of institutional mechanisms to scale out beyond the *kebele*).

Modern programs, especially the new SLM Program and projects under its umbrella, are taking a more systematic approach to targeting small watersheds, but in a larger watershed planning context. The use of LLPA and the CBPWD guidelines (Lakew Desta et al eds, 2005a, b) apparently has made a difference in terms of achieving better and more sustainable outcomes (e.g., ANRS-BoA & GTZ 2003; AH Consulting 2010). A far more important feature of recent programs, however, is the explicit and clear focus on enhancing farmers' incomes and food security, for example through support for RWH and micro-irrigation, agro-forestry, and income generation (e.g., Nedassa 2002; Lakew Desta et al eds, 2005a, b). Improved water and land management should be a means to improving peoples' lives, not an end in itself. On the other hand, many issues remain. Among them are: 1) the continuing use of FfW (or cash for work) which may undermine ownership and incentives to maintain infrastructure[37]; 2) the focus on low-potential food-insecure areas and exclusively on

[35] Nevertheless the neo-Malthusian environmental policy narrative driving the SLM program remains, as seen for example in the constant debates by researchers from IFPRI and its partners about the relevance of their findings for Malthusian versus Boserup hypothesis (growing population density drives innovation and intensification) views; see for example Pender & Gebremedhin 2006; Benin 2006.

[36] In one SCRP research site (Gununo), farmers in the control watershed were forced to destroy previously-constructed bunds (Beshah 2003:122-123)!

[37] This may be reduced by the practice of combining FfW and "voluntary" labor contributions by communities.

community land (the World Bank's SLM Project proposes to shift this to 'high potential/food secure' areas and to include private farm and homestead land as well as community land); 3) the continued use of quotas and standardized packages; and 4) the continued high turnover of DAs and other technical staff combined with periodic institutional re-structuring. Finally, while the shift to more "participatory" and "community-driven" approaches is a positive trend, its implementation at field level remains mixed; approaches emphasizing the spread of "best practices" are inherently top-down. There is no attempt to work with farmers and communities as partners and engage them in a creative innovation process to solve their own problems.

6. Evolution and Outcomes of Major Rainwater Management Research Programs

A large number of major RWM-SLM research programs have been implemented in Ethiopia since the 1980s. Most of them, especially in the early years, focused more on the causes, processes and impacts of land degradation and the outcomes and impacts of various SWC interventions. This does not include the equally large number of research programs addressing other broad policy, poverty and development issues, for example the current Ethiopian Strategy Support Program (ESSP)[38]. While this report is based largely on the published outputs of these programs and projects, obtaining information about the research programs themselves – their goals, capacity building and knowledge contributions, impacts on policies and implementation strategies – has been difficult; we do not have very good information on this dimension. This section attempts to briefly characterize a few of the major programs, with the understanding that the following section (7) will document many of their major contributions to understanding AWM in the Ethiopian Highlands. A proper assessment of the impacts and value added from the investments in internationally supported research programs in Ethiopia would be ambitious but potentially enlightening.

6.1 Early land degradation research programs

Two major research programs on land degradation were initiated in the 1980s. The Ethiopian Highlands Reclamation Study (EHRS) was implemented in 1983, a year after the Soil Conservation Research Program (SCRP) was initiated (as discussed above in section 3.2). The EHRS was requested and funded by the MoA (using a World Bank loan) and implemented by FAO. It synthesized existing knowledge in a comprehensive manner (even drawing on initial SCRP field research findings). It attempted to analyze and explain the causes, processes, extent and types of degradation in the Highlands; identify the areas and peoples most critically affected and threatened; estimate the present and future rates and costs of degradation in different areas; assess returns to tackling degradation relative to alternative development options; evaluate what was already being done to combat or avoid degradation; and finally, to systematically review the options for improving current programs and formulate a coherent strategy both for reclaiming already degraded lands and for conserving lands threatened by degradation (FAO 1986a, 1986b; Yesuf et al 2005; Yitaferu 2002). EHRS findings have been referred to in section 3.2 above: its estimates of the rates and impacts of land degradation are authoritative and continue to be quoted today. Its findings undoubtedly provided justification to the early SWC investment programs and influenced early policies. A recent critical review of EHRS, SCRP and other assessments of the rates and costs of land degradation has

[38] Implemented by EDRI and IFPRI on request of the Government, this program provides research inputs for agricultural policy and implementation strategy.

pointed to numerous weaknesses, for example focusing exclusively on land degradation from water and ignoring other causes, ignoring downstream impacts, and over-estimating impacts of degradation on crop yields (Yesuf et al 2005).

SCRP was in a formal sense implemented jointly by the Soil and Water Conservation Department (SWCD) of the MoA and the University of Berne with Swiss and Ethiopian government funding. Between 1981 and 1987, seven long-term research sites were selected in different Highland agro-ecological zones. Three are in the Nile Basin (Dizi [Illubabor], Andit Tid [Shewa], and Anjene [Gojam] which is in the Abay). In each site, a system of long-term monitoring of climate, runoff from small catchments and multi-scale plots, measures of soil loss and catchment sediment loss, seasonal land use and crop production, land cover changes and social and demographic features was initiated. This monitoring was complemented by numerous special studies on various topics, monitoring of soil conservation measures implemented in these and other catchments by government agencies and NGOs, and the effects of these on natural resources, productivity and farmers' attitudes. SCRP may have produced over thirty Ph.D. dissertations (T Amede, personal communication). The program claimed to interact closely with various implementation agencies, advising them on technologies and approaches to soil and water conservation. However, Beshah (2003) claims that the weak institutional linkages between the project and ministry agencies contributed to rising tensions and to the new government's decision in 1995 to close the project, a claim we could not verify. A comprehensive database was developed from this long term monitoring and published at the end of the project by the SCRP (2000, cited in Hurni et al 2005 and other places; see also FAO 1986a: 230-231)[39]. Like subsequent projects, this one combined direct research by international and local researchers and students with institutional strengthening, training and policy advice. Significantly, other researchers have drawn on the detailed long-term data base, often returning to the same research sites for further research (e.g., Beshah 2003, who returned to two SCRP sites to assess project impacts and farmers' perspectives; see also Shiferaw & Holden 2001). The sites themselves are now managed by regional research institutions. SCRP seems to have been a traditional research project in terms of its methodologies and strategies; it did not pretend to be participatory or interdisciplinary, and its implementation pre-dates current innovation system perspectives. Although much has been learned from SCRP, Beshah (2003:202), based on field work in two if its sites, concludes its 17-year intervention failed to meet its main objective, "to develop and promote ecologically sound, economically viable and socially acceptable conservation measures". Nevertheless, SCRP clearly contributed a great deal in terms of new knowledge and capacity building.

Since 2001, the University of Berne through its Swiss National Center of Competence in Research [NCCR] North-South Program in Ethiopia has continued to support research on natural resources management in the Ethiopian Highlands. This has included several important Ph.D. theses, whose results are discussed in Hurni et al (2010); however we have not been able to obtain copies of these. Several other European and American universities have supported Ethiopian and foreign Ph.D. students' research on water and land management in the highlands, though without the same official endorsement and engagement as SCRP. These include Wageningen Agricultural University

[39] Dates for the actual beginning and end of the SCRP vary; work seems to have begun in 1982 and ended by 1998, with additional time for reporting. Sites were decentralized to regional research systems beginning in 1996. See Beshah 2003. We were not able to obtain a copy of the SCRP 2000 data base.

(e.g., Bekele-Tesemma 1997; Beshah 2003; Bewket 2003 and various papers; Aklilu Amsalu 2006; Aklilu Amsalu & de Graff 2006). The strength of these studies is their combination of integrated socio-economic and technical research and in-depth case studies on small watersheds. The Agricultural University of Norway has supported some of the classic work on policy impacts on farmers' incentives related to SWC (e.g., Shiferaw & Holden 1998, 2000, 2001; Holden et al 2004; Kassie et al 2009a). Katholiek Universiteit Leuven (Belgium) has also supported a great deal of work of various disciplines (e.g., Nyssen et al 2005, 2007; Gebreegziabher et al 2009; Segers et al 2008). The University of Gothenburg School of Business, Economics and Law has supported numerous economics researchers whose work on the micro-economics of sustainable land management is very useful (e.g., Kassie et al 2009b; Yesuf and Köhlin 2009; Ekbom et al 2009). Cornell University, in association with the AMAREW project, has also supported recent work (e.g., McHugh et al 2007; Liu et al 2008). The results of some of the studies supported by these universities are discussed in section 7, below.

6.2 CGIAR-supported research programs

The CGIAR centers have been very active in Ethiopia for decades, generally under the overall legal umbrella of ILRI which has a major campus in Addis Ababa. A complete discussion of their work, even relative to RWM, would constitute another separate paper. We therefore limit our discussion to selected activities by ILRI, RELMA-ICRAF, the African Highlands Initiative (AHI), IFPRI, IWMI and the CPWF[40].

ILRI's work is largely focused on the full range of topics related to its mandate, livestock management. In recent years, working with IWMI, its scientists have developed and applied a conceptual framework for understanding how to improve the productivity of water that supports livestock, "livestock water productivity" (LWP) (e.g., Peden et al 2007, 2009a; Haileslassie et al 2009a, b). This is discussed in more detail below in section 7. ILRI scientists[41] also developed a broad bed maker plow for use in heavy vertisols; versions of this plow have been widely adopted and have been shown to have had significant impacts (e.g., Rutherford 2008; see also Temesgen et al 2009). ILRI is acknowledged for its contribution to the CBPWD guidelines (Lakew Desta et al eds, 2005a, b). Currently ILRI implements the "Improving Productivity and Market Success of Ethiopian Farmers" (IPMS) Project. IPMS is based on a participatory market-oriented approach that is intended to facilitate adoption of technology and institutional innovations. It is built around four principles: value chain/market orientation, innovation system perspective, participation, and sensitivity to environment, HIV/AIDS and gender (IPMS M&E Team 2009; Tegegne et al 2009). IWMI is a relative newcomer to Ethiopia compared to other CGIAR centers, but has rapidly established an important niche and strong partnerships, especially with Ethiopian institutions and ILRI. Its work is reported below as much of its RWM work has been supported by the CPWF.

AHI was an interdisciplinary eco-regional program of the CGIAR, the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and national research institutions

[40] The Regional Land Management Unit (RELMA) at ICRAF (the World Agroforestry Center) has supported very important research on sustainable water and land management for years; but few publications were specific to Ethiopia. A lot of the work led by Rockström (e.g., Rockström et al 2009) included Ethiopian sites. RELMA has also published important methodologies and case studies from Kenya (e.g., Malesu et al 2006a, 2006b).

[41] ICRISAT may also have been an important partner (T Amede, personal communication) though this is not documented by the recent *ex post facto* evaluation of Rutherford (2008).

which operated from 1995 until recently in benchmark sites in several East African countries including Ethiopia. It sought to develop new approaches to improving NRM at farm and landscape level. Its emphasis changed over time, but in its latest phase it emphasized participatory IWM and development of methodologies to operationalize this (e.g., German 2006; German et al 2007, 2008; Amede et al eds, 2004; Amede et al 2006). All its benchmark sites were characterized by high population density, degradation of natural resources, declining agricultural productivity, and high levels of poverty. AHI research results emphasize the critical importance of strengthening local collective action institutions for reversing resource degradation and raising productivity. AHI methodologies for interdisciplinary participatory action research are useful guidelines for RWM research.

An extremely important source of research-based insights into the factors affecting adoption or rejection of SWC-RWM technologies and their outcomes and impacts, is the body of outputs from the project on “Policies for Sustainable Land Management in the Ethiopian Highlands.” This project was implemented in three regions, Tigray, Amhara and Oromiya (though there are few publications on the latter). It received financial support from Switzerland, Norway, Italy and the USA in addition to ILRI and IFPRI core resources. The project was led by IFPRI and ILRI in partnership with regional universities and research institutions in Ethiopia, and several European and American universities. Its objectives included improving understanding of land degradation and its causes in the Ethiopian Highlands, identifying potential pathways to development, identifying policies and strategies that would facilitate productive sustainable poverty reduction, and strengthening capacity to conduct socio-economic and policy research related to sustainable land management. In both Amhara and Tigray, large-scale sample surveys of households carried out in 1999-2000 provided the core data set. Earlier results of the research are reported in workshop proceedings (Jabbar et al eds, 2000; Gebremedhin et al eds, 2003) and papers (e.g., Benin et al 2003). Finalized versions of some of these papers along with papers from other East African Highland areas were published in Pender et al eds (2006) and numerous IFPRI discussion papers and journal articles. There is no information on the capacity building outcomes of this project, but the research provides important insights that we present below in sections 7 and 8. It was clearly not designed as an “action research” or innovation system project.

The CPWF has supported several important projects during Phase 1 that provide the foundation for research to be done in phase 2. Molden et al (2009) synthesize a large amount of data on the Blue Nile and identify, in broad terms, opportunities for improving the productivity of water used in agriculture; this is the “basin focal project” report. Peden et al (2009a) synthesize the findings of another project, on Nile Basin livestock water productivity (LWP). The conceptualization of LWP, demonstration of the critical importance of livestock-water interactions and the potential for achieving very high levels of WP through better management of livestock have offered new and innovative perspectives on potentially profitable and sustainable AWM interventions (see section 7, below). Awulachew (2010) reports in detail the main findings from a project that assessed the potential for improving land and water management in the Ethiopian highlands and its impact on stakeholders downstream; these impacts are overwhelmingly positive, suggesting that downstream stakeholders have a large stake in promoting better resource management upstream. Results from this project have been referenced above in section 3 (see Awulachew et al 2008a; Awulachew et al eds, 2009, Yilma & Awulachew 2009), and are discussed further below. Important papers have also been produced under the project on “Improved Planning of Large Dam Operation: Using Decision

Support Systems to Optimize Livelihood Benefits, Safeguard Health and Protect the Environment;" for example McCartney et al (2010) assess the current state of Lake Tana and the likely serious hydrological and environmental impacts if planned future developments are implemented.

6.3 Nile Basin Initiative research programs

The Nile Basin Initiative (NBI) is becoming an increasingly important stakeholder for research and development in the Nile Basin. Indeed, IWMI led a study in cooperation with the NBI Secretariat aimed at identifying research that could support NBI goals (Mohamed & Loulseged 2008), though there has been no follow up. NBI's "Efficient Water Use for Agricultural Production" (EWUAP) project was one of the eight projects of the Nile Basin Initiative's (NBI) Shared Vision Program (SVP). Implemented from 2006 to 2009, it was designed to bring together regional and national stakeholders to develop a shared vision on increasing the use and efficiency of water for agriculture. Using both local and international consultants, EWUAP produced a large set of reports synthesizing existing knowledge and making recommendations for future AWM development. Examples include documents providing an overview of AWM in the Nile Basin (Anderson 2008), identifying best practices, guidelines and investment action plans for RWH and SSI (Anderson and Burton 2009a-e), and improving productivity on large-scale irrigation schemes (Bastiaanssen & Perry 2009). EWUAP also commissioned national assessments in Ethiopia that are moderately useful syntheses (Gezehegen 2006, 2008). Overall, EWUAP provides useful and balanced information on the RWH, SSI and large-scale irrigation potential of the Nile basin; but the Ethiopian Country Overview (Annex D, page 2) of the Nile AWM report (Anderson 2008) exhibits a strong bias toward large-scale irrigation: it states that improvements in rainfed agriculture alone will not be enough to meet future food demands; the country must increase the extent of irrigation development and improve the productivity of existing irrigation systems; it re-emphases this point in a special box, stating, "Growing population pressure in the highland areas of rainfed agriculture on a rapidly declining natural resource base has secured irrigated agriculture a prominent position on the country's development agenda."

Nevertheless, the Eastern Nile Technical Regional Office (ENTRO) of the Nile Basin Initiative has commissioned important studies on the potential for improving watershed management, and therefore RWM in rainfed lands in the Eastern Nile; we drew on these reports above in characterizing the Abay Basin (see Hydrosult 2006 for the Ethiopia country report, Hydrosult 2007a-c for reports on the three Eastern Nile sub-basins including the Abay)[42]. Building on these studies, ENTRO commissioned Halcrow Group and Metaferia Consulting Engineers (2007) to prepare a detailed Project Implementation Plan for a 'fast-track' "Integrated Watershed Management (Ethiopia) Watershed Project." This is a component of the Tana Beles Integrated Water Resources Development Project discussed above (section 5). Its development objective is "Improvement of livelihoods of rural households living in upper catchments of Ribb, Gumera and Jema watersheds through enhanced productivity and promotion of sustainable land use practices." The current status of this project is not clear; but the detailed report and annexes contain a great deal of information on the proposed watersheds. Its implementation strategy is based on the CBPWD guidelines.

[42] The assessment of MERET by Zeleke 2005 was also commissioned by the ENTRO Watershed Management Project.

6.4 Conclusions on outcomes of RWM research programs

The research programs reviewed here, complemented by many others large and small, have produced a large body of research findings that provide a foundation for the next phase of CPWF phase 2. Earlier research programs focused more on technical than socio-economic dimensions, but later research has made up for this. Recent research programs have emphasized the need for integrated interdisciplinary research, carried out with farmers' participation (though in most cases not quite in a creative partnership to promote innovation). The extent to which these research programs have directly influenced policies and implementation programs is not clear. It is likely to be substantial, but in an informal, indirect and inefficient manner. Most research programs sponsor workshops to which policymakers are invited; but few directly involve them or other stakeholders from the early conceptualization of the research. None of the research programs reviewed here has published project reports or external evaluations documenting their outputs and impacts[43]. This is in contrast with most implementation projects which are required to produce such reports by the financing institution's rules. Another problem is that while most published research is extensively referenced, the actual results reported are contradictory to those in other reports, with no clear explanation. Contradictory research results are an issue faced in section 7.

7. Selected Findings from Studies on Rainwater Management Interventions

There are now many studies on the dynamics of land use changes, land cover and land degradation in the Ethiopian Highlands over the past few decades. Indeed agricultural expansion has continued for the past 2-3 millennia, and deforestation leading to increasing grassland and cropland area as well as forest re-generation processes have been underway during this entire period. However, from the mid-20th century as population growth rates spiked and land policies and institutions changed, a large increase in croplands has occurred, at the expense of forest and grassland. In the last 20 years, more detailed research at localized levels has found highly dynamic systems, such that while one can generalize about macro-level trends, one cannot assume these trends characterize every locality: diversity is the rule (see Hurni et al 2010 for an overview; examples of case studies include Tegene 2002; Bewket 2003; Beshah 2003; Aklilu Amsalu et al 2007; Nyssen et al 2009). Nyssen et al (2009) studied land use changes from 1965 to the present in a catchment of the Wag zone of Amhara (headwaters of the Tekeze) and found that people have abandoned mountain agriculture allowing woody vegetation to expand, and have increased their irrigated area. Aklilu Amsalu et al (2007) found in the Beressa watershed (North Shewa, in the headstream of the Blue Nile) that cleared areas replanted with plantations have replaced much of the natural vegetation, while grazing land has expanded at the expense of bare land and cropland. Farmers have gradually shifted from annual cropping (as yields have not increased) to tree planting and livestock; they have invested little in SWC practices, resulting in high rates of erosion and soil nutrient mining. This diversity in local processes is a result of farmers' responses to varying climate, soils, altitudes and temperatures interacting with socio-economic processes such as urbanization, market access, and changing policies and institutions.

[43] AHI may be an exception; T Amede (personal communication) says it published an external evaluation in 2002, but we could not find this on the AHI website (http://worldagroforestry.org/projects/african-highlands/archives.html#other).

Most of the research in Ethiopia has approached sustainable land and water management from a land management perspective; i.e., focusing primarily on how to reduce land degradation processes. But the most serious erosion processes in the Ethiopian Highlands are water-induced (sheet erosion, rill erosion, etc). Clearly the same technologies and practices have implications for water management – indeed they can be seen as means to manage rainfall though with both environmental and productive goals. Improving the productivity of water in rainfed agriculture is to a large degree a function of improving land management as a means to obtain more 'crop per drop' (Stroosnijder 2009; Bossio et al 2007, 2010; Rockström et al 2009). The number and range of RWM-SWC technologies available to farmers is huge. Mati (2005) describes over 100 in use in eastern Africa; the Ethiopian page on the WOCAT website (www.fao.org/ag/agl/agll/wocat/) lists over 40 technologies in use; while Lakew Desta et al eds (2005a) also list a large number. The MoARD claims to have documented over 50 technologies and 27 approaches in the past decade (MoARD-SLM Secretariat 2008:25). Mitiku et al (2006) provide a good discussion of those SWC technologies most commonly used in Ethiopia – though curiously giving less attention to RWH technologies. These include both indigenous practices and those introduced from outside Ethiopia. Reviewing experiences with all of these technologies would not be useful — readers can consult the references provided.

This section reviews a few of the most commonly used technologies that have been evaluated by researchers. Its focus is on the findings of researchers and only where useful refers to the findings of project evaluations. The next subsection (7.1) examines the question of the impact of policies and farmers' incentives for investing in RWM technologies. The following subsection (7.2) reviews the performance of a selection of commonly used SWC-RWM technologies and management practices in terms of their technical performance, impact on productivity, economic performance, and farmers' perceptions. It is important to note that many SWC interventions are implemented on areas of watersheds that are common land, i.e., not allocated for private farming; until recently FfW programs were implemented only in such areas. In other cases, SWC and RWH practices are introduced on farmers' own plots.

7.1 Policies and farmers' incentives to invest in RWM technologies

Farmer knowledge of land management problems

While the advantages of adopting improved SWC-RWM technologies may seem obvious to the casual outside observer, this is not always the case from farmers' perspectives in the Ethiopian Highlands – they often view the performance of specific SWC technologies differently than outside 'experts.' Some researchers argue that even when farmers apply indigenous SWC technologies, they are not very effective; and that farmers do not have a good understanding of land degradation processes (e.g., Hurni et al 2010). Others point out long-standing cases of sustainable land and water management as evidence that indigenous practices are effective and farmers are knowledgeable; an often-cited example is Konso in southern Ethiopia[44] (see Beshah 2003; Mitiku et al 2006). Detailed field studies have found that farmers are well aware of land degradation and the need for measures to management water and land more effectively (e.g., Bekele-Tesema 1997; Bewket & Sterk 2002; Beshah 2003; Bewket 2007; Aklilu Amsalu & van de Graaff 2006; Zegeye et al

[44] This is a now-famous case of effective indigenous SWC that is over four centuries old. Beshah 2003 provides a detailed analysis. Bekele-Tesema 1997: 90ff provides a detailed description of indigenous SWC technologies and skills.

2009). For example Aklilu Amsalu & van de Graaff (2006), based on research in Beressa watershed in the Upper Abay Basin, state that a large majority of farmers reported having erosion problems, recognized the need for conservation, believed erosion can be halted, and practiced a range of practices for erosion control (especially contour plowing, drainage ditches, and stone terraces/bunds – which most farmers considered to be ancient indigenous practices) and fertility improvement (e.g., rotation, organic fertilizer). However, farmers tended to recognize serious erosion only when rills and gullies appeared in their fields; and tended to adopt practices perceived as having immediate benefits. Nevertheless SWC programs should consider farmers' knowledge and practices as the starting point for bringing about improvements. Zegeye et al (2009) found that farmers recognize the need for SWC practices and do use several indigenous measures, for example ditches and soil bunds; but they are skeptical about introduced measures such as *fanya juu,* which are seen as too time-consuming and labor-demand (see subsection 7.2). In a particularly degraded highland area of North Wollo (Amhara), Elias & Fatnaye (2000) found that farmers have abandoned land and nutrient management practices of the past including bunds, ditches and contour plowing – again pointing to the considerable variation among watersheds. On the other hand, in the SCRP research site above Lake Maybar (Awash basin), farmers estimated that fields under indigenous SWC practices (various types of bund) had 50-70% higher yields (Beshah 2003).

Impact of policies and household characteristics on adoption of SWC practices

If farmers are not adopting better water and land management practices there must be other reasons than ignorance for this. The main reasons identified by researchers have to do with policy and market imperfections, household characteristics, the implementation strategies used by government to promote SWC, and the appropriateness of the technologies themselves (discussed in section 7.2). Studies by economists have found that farmers' recognition of the erosion problem and awareness of options is a necessary but not sufficient condition for adoption and continued use of SWC technologies. Both rural market conditions and household characteristics are important: older age and larger family size reduce the likelihood of adoption and retention; and female-headed households' productivity is especially low (a finding confirmed by Benin (2006) for Amhara and Pender & Gebremedhin (2006) for Tigray). Intensification of land use in response to population pressure may lead to adoption of land conservation practices up to a point; but poor rural households "caught up in a poverty-population-environment trap" find themselves in a worsening situation and often cannot adopt new practices. In fact, adoption of conservation technologies (mainly level bunds and graded *fanya juu*) had no positive impact on land productivity in the short run in these studies, and some farmers were destroying those built previously through FfW programs (see also Shiferaw & Holden 1998). There is therefore a need for conservation technologies that provide immediate benefits through improved yields, and stronger institutional incentives, for example subsidies, credit facilities, secure land rights, and integrated extension services. Rural market imperfections and serious subsistence constraints imply farmers are not motivated by a profit motive alone; they are concerned about meeting basic consumption needs. Farmers anticipating the same or lower yields and/or substantial installation costs are reluctant to invest. Finally, the same set of studies found that while access to low-wage non-farm income substantially improved household incomes, it reduced their incentives to invest in conservation, leading to more degradation (Shiferaw & Holden 1998, 1999, 2000; Holden et al 2001, 2004[45]). Similarly, a later modeling study by Yirga & Hassan (2010) found that small farmers heavily discount

[45] This research was carried out in one of the SCRP sites, Andit Tid, North Shewa (Amhara).

future private gains leading to over-exploitation of soil nutrients. They recommend stronger policy support to achieve the apparent high social gains obtainable from better use of soil resources.

Aversion to risk in a context of "market and institutional imperfections" is another serious factor identified by economists. Dercon & Christiaensen (2007), based on data from the Ethiopia Rural Household Survey carried out in 1994-1999 on 1477 households, found, even after controlling other household and village variables, the risk of low consumption when harvests fail discourages use of fertilizer. Kassie et al (2009b) using two years of plot-level data from Amhara[46] assessed the impact of production risk on land-management technology adoption. They found that production risks had a significant impact on fertilizer adoption but this impact was not observed for conservation technologies. However, expected returns on investments had a positive impact on fertilizer adoption and intensity of use as well as conservation adoption. Yesuf and Köhlin (2009), using the same data, found that a household's decision to adopt fertilizer significantly and negatively depends on whether the same household had adopted soil conservation though the reverse was not significant: SWC adopters were 16% less likely to use fertilizer, even though returns to fertilizer would be far higher if farmers adopted both. The authors suggest binding financial constraints force a choice. They advocate efforts to reduce poverty and asset scarcity in the short term, and development of credit and insurance markets in the long term.

Yesuf and Köhlin (2009) found no impact on adoption from land insecurity, a point on which findings have been somewhat inconsistent. Bewket (2003) also failed to find any negative impacts of land tenure or periodic land redistribution on SWC investments except in communal lands in Chemoga watershed; but in a nearby watershed over 73% of farmers said periodic redistribution discourages them from adopting SWC measures (Bewket 2007). Benin (2006), based on a large-scale sample survey in Amhara, found that land redistribution was directly and positively associated with higher value of crop yield, especially in high-potential areas but in Oromiya the same authors found no such impact (T Amede, personal communication). They also found that the incidence of stone terraces, live fences, trees and check dams was significantly higher on owner-cultivated than rented-in plots, while drainage ditches were higher on the latter. Owner-cultivated plots were also more likely to use crop rotation and plowing-in of residues in high-potential areas only but also had somewhat lower yields than rented-in plots, while in the same areas rented-in plots were more likely to use improved seeds (for maize) and in all areas more likely to use manure. Overall Benin (2006:251) concludes that households feeling secure about their holdings were associated with higher crop values, especially in high-potential areas.

7.2 Performance of selected technologies

This subsection is largely based on reported research examining the performance of selected SWC-RWM technologies. The selection in turn is largely based on the availability of studies. The studies reviewed are mainly of two types: those focused on assessments of specific technologies; and those with a wider focus that also report on performance of specific technologies or practices. To our knowledge, there is only one study that systematically compares performance of a range of AWM technologies – in this case impacts on poverty (Awulachew et al 2009; Kato et al 2009 assess the performance of SWC technologies across regions as well; both are discussed below). It is also

[46] Data collection in 2002 and 2005 in Amhara was supported by SIDA, presumably in association with SARDP; the sample included 724 households and 3369 plots, all above 1500 masl.

notable that few of these studies assess performance of interventions in a landscape perspective. As noted above, there is also a bias in the existing literature to examine the performance of technologies from a land, not water management perspective. As noted above, early programs promoted SWC technologies with a primary goal of resource conservation (or 'ecological effectiveness'); with experience it is now recognized that economic or productivity-enhancing effectiveness is also critical, even primary, and both are necessary (e.g., Simane 2003; Ersado et al 2003). In this review, to the extent feasible, we use the following broad assessment criteria: 1) technical performance; 2) impact on agricultural productivity; 3) economic performance; and 4) farmers' perceptions.

We review the following RWM-SWC technologies and practices: household RWH ponds; shallow wells; a range of types of terraces or bunds (e.g., *fanya juu*, stone and soil bunds and ditches or trenches)[47]; conservation agriculture (e.g., reduced tillage, use of furrows and beds); livestock management for water productivity; agro forestry; and protection of common lands through "exclosure" and promotion of collective action on small watersheds. We have not reviewed community-managed SSI as we consider this topic outside the definition of RWH used; and we have not found any studies on the performance of deep wells or of human- or fuel-powered pumps and drip irrigation kits even though they are in use in some areas of Ethiopia and hold great future promise. Indeed, we have actually found very little information on the performance of agro forestry from a water productivity perspective, and the LWP studies we found focus on cattle, excluding small livestock (goats, chickens, etc). Annex Table 5 summarizes much of the information presented in this subsection.

RWH ponds

For more than a decade, Tigray National Regional State more than others placed very high priority on promoting small communal dams for irrigation and livestock. This program never reached the scale envisioned by the regional authorities, and faced numerous problems. From the early part of this century, there was a shift in emphasis to promotion of small household-level RWH ponds, shallow wells and water diversions on small rivers; Amhara National Regional State also adopted this focus. In the initial years, ponds were promoted as a top-down campaign, with quotas to be filled at *woreda* and *kebele* levels by DAs. In October 2003, the United Nations estimated 70,000 ponds and tanks had been constructed during the previous fiscal year alone in Tigray and Amhara; quite impressive but this was only about half the planned quota. ANRS had a target of 365,000 for the 2003-2004 fiscal year, though this was undoubtedly scaled down (Rämi 2003). The sizes, shapes, lining materials (concrete, clay, plastic [geo-membrane]) and uses of RWM ponds vary considerably. Uses of the water are multiple: irrigation of high value vegetables, fruits, and seedlings, watering livestock, and household use. Hagos et al (2007) report that the size of most ponds is roughly 13m width by 13m long by 2.5m deep. Landell Mills (2004) reports that in Tigray in the early years only one trapezoidal design was encouraged, theoretically in four possible sizes but in practice most were 12m X 12m X 2.5m. Capacities ranged from 57 m^3 to 110 m^3 and even 182 m^3. Lakew Desta et al eds (2005a:104) provide basic guidelines for constructing round or trapezoidal farm ponds. From the beginning, assessments have found major problems in implementation, technical quality, location,

[47] The SCRP focused its research on soil and stone bunds and *fanya juu* combined in some cases with grass strips, paying less attention to other practices (Mitiku et al 2006).

acceptance by farmers and other issues (e.g., Rämi 2003). Nevertheless the program has continued, and over time it has been adjusted based on lessons from experience.

Most studies agree that these household level ponds have a high potential in terms of income generation from high-value vegetables and improving food security (e.g., Ayele et al no date; Tesfay 2007; Landell Mills 2004). Some studies found overall positive impacts. For example, Ayele et al (no date) concluded from their survey of farm households in four regions that "visible impact" on food security and livelihoods could be seen in most households, especially in *Woina Dega* and K*olla* agro-ecological regions; in general they reduced the hunger time by about a month. Adgo & Teshome (2008), based on research in a *woreda* in North Showa (Amhara), report very positive outcomes in all agro-ecological zones, with high yields of profitable crops such as onions; Amha (2006) also found positive impacts in a *woreda* in SNNP, while Landell Mills (2004) found in Tigray that RWH ponds have high returns in backyard plots but not away from homes, though better quality control, and post-construction O&M and extension are needed. Most studies found that RWH ponds built close to homesteads and used for irrigating gardens are more beneficial than those built in more distance fields for supplementary irrigation of staple crops (which had initially been the intention of government). Awulachew et al (2009) in their survey of use of AWM technologies and poverty also found that access to ponds and shallow wells is associated with lower poverty levels.

Nevertheless, not all studies have been so positive. Ayele et al (no date) hedge their positive comments based on an economic analysis suggesting that both the cost-benefit ratio and net present value are negative over periods of five and ten years. Tesfay (2007) found in a survey of three *woredas* in Tigray and Amhara that over half of the ponds surveyed were not in use: there was a lack of interest attributed to their top-down implementation, and there were design problems. A survey of nearly 15,000 household ponds (and a few shallow wells) in Amhara found that only 22% were functional, 70% not functional, and the balance had been destroyed; this was attributed to major technical, social and environmental problems (Wondikum & Tefera 2006). The methodologically most sophisticated study, carried out on a sample of 650 households in Tigray, found that ponds were not fully exploited and did not contribute to household income or welfare. Households with ponds (and shallow wells) were therefore no better off than those without; and they were also important factors in a high prevalence of malaria except in the high altitudes. These findings were very controversial when first reported. Confirming the study by Ayele et al (no date), the same study raises serious questions about the value of these investments from both private and public investment perspectives (Hagos et al 2006, 2007). However, Adgo & Teshome (2008) came to the opposite conclusion based on a study of RWH ponds in one *woreda* in Amhara. They found farmers were using the ponds to irrigate high-value vegetables, fruit and seedlings on about 100 m^2 plots. The additional gross income from two crops per year (main rainy season and dry season) was \$301, \$212, and \$174 respectively in the highlands, middle and lowlands respectively. This does not include water consumed by livestock and used by households. Using a 10% discount rate over seven years, they calculate a high net present value of \$1223, a financial internal rate of return of 203%, and return on investment of 483% averaged among the three agro-ecologies. They also find high net returns to labor, and high levels of WP.

Kassahun (2007), Amha (2006) and Segers et al (2008a, b) found that targeting is a problem: women-headed and generally poor households were not benefiting from RWH ponds. Kassuhun (2007), whose study was done in five *woredas* in Oromiya and Amhara, attributes this to their inability to

contribute to collective labor. The anthropological study in Tigray by Segers et al found that people participated in the RWH pond program as a means to gain access to FfW under PSNP; therefore the most needy people were excluded and those with ponds do not sustain and use them. Other problems identified include water lifting (most people use buckets), accidents in the absence of pond covers, and health issues, especially malaria in lower altitudes (e.g., Amha 2006; Hagos et al 2006).

The conflicting findings of various researchers may in part be a product of different methodologies used, sampling issues, or researcher biases. But they undoubtedly also reflect differences in implementation strategies (top-down quota-driven programs are likely to exhibit lower performance than demand-driven programs), program quality (i.e., proper location, design and construction), access to markets for high-value crops, and other factors. Several studies lament the lack of good extension services to help people improve productivity (i.e., WP) – this seems to be a major shortcoming. Another problem seems to be inefficient water-lifting equipment: most people use buckets, as they do not have access to manual or power pumps. We conclude that RWH ponds may indeed be a potentially important technology, but their implementation needs improvement, and additional support is needed in terms of extension advice, marketing information, and water lifting technologies.

Shallow wells

Many of the studies of RWH ponds simultaneously examine the performance of shallow wells. The dimensions of shallow wells are generally 3-4m in diameter with depths ranging from 3-15m (Tesfay 2007). Generally, researchers have found more positive impacts of shallow wells than of RWH ponds (e.g., Ayele et al no date; Tesfay 2007). Whereas RWH ponds require a catchment from which runoff can be channeled to the pond, shallow wells are appropriate where shallow groundwater is abundant. While shallow wells are said to be cheaper to construct, they frequently lead to conflict over water: unplanned expansion on watersheds has emerged as the most serious problem they face. We conclude that while shallow wells seem to perform better than RWH ponds overall, their use is restricted to locations with sufficient groundwater; and more effective watershed planning and regulation is needed to make balanced use of the aquifer. There is evidence that IWM programs that reduce run-off and erosion and restore the vegetative cover in the upper watersheds can regenerate the groundwater (and springs) – therefore shallow wells can be part of the IWM planning repertoire. Some of the concluding observations on RWH ponds also apply to shallow wells: the need to improve program implementation, provide effective extension and marketing advice, and make water lifting and application technologies more easily available.

Bunds and terraces

A large variety of types of terraces and bunds are used in Ethiopia, including both indigenous and introduced technologies. Lakew Desta et al eds (2005a, b) include basic design guidelines and advice on which kinds of terraces are appropriate in specific environments. Mitiku et al (2006) also provide a clear discussion of the types of structures and how to choose and combine them to meet specific conditions. These SWC technologies have been actively promoted since the 1970s to 1980s by government and donors, as the central features of past and current SLM projects and programs. Not surprisingly therefore, there is also a very large literature evaluating their technical performance, economic and productivity performance and social acceptance. As is the case with RWH ponds, the conclusions of researchers also vary considerably. Some of the studies have been discussed above in

subsection 7.1 and these are not repeated here. We are again selectively reviewing literature, focused on the following terracing technologies: *fanya juu,* stone and soil bunds, and to a lesser extent ditches (cut-off drains).

Fanya juu

Fanya juu is a Swahili term for terraces made by digging a trench about 60 cm wide along the contour and throwing the soil upslope to form an embankment. It therefore reduces soil erosion while retaining water. It is appropriate in areas with rainfall between 500-1000mm; planting vegetation along the terrace helps stabilize it and provides a source of fodder (Mati 2005:10-11). They have been widely, even enthusiastically, promoted by technical experts throughout East Africa including Ethiopia. The research results on their performance in Ethiopia, and especially farmers' responses, are somewhat mixed but largely negative. Adgo & Teshome (2008) assessed the performance of *fanya juu* and grass strips on an SCRP site, Anjene watershed, West Gojjam Zone (Amhara) and found they continue to be maintained and their use has even expanded to other neighboring villages. They found that in the upper, middle and lower catchments, teff productivity has increased more than twofold compared to fields with no terraces, and farmers can now produce two barley crops per year as a result of improved moisture availability. Farmers with terraces are beginning to grow maize as well, in the middle and lower catchment. The net returns for barley and teff are very positive with terracing, though maize returns are negative; without terracing, returns are negative for all three crops. WP is doubled with terraces. Despite needing more family labor for terrace maintenance and crop management, marginal returns to family labor for teff and barley (but not maize) are also high (over $5.00/day); a financial analysis also gives very positive returns.

These very positive returns are not replicated by other studies. Interestingly, Kassie et al (2008) carried out a cost-benefit analysis of *fanya juu* and grass strips using a sample from the same Anjene watershed studied by Adgo & Teshome (2008) — with contradictory results. The sample is 148 households and 1290 plots; and the econometric analysis is more sophisticated than the other study. All of their models tell a consistent story: the value of crop production on plots with bunds is *lower* than plots without bunds. This applies to both "old" (over 15 years old) and "new" bunds. Over the entire sample, bunds reduce mean value of output by $19.00/ha, i.e., over 15%. Matching bunded and non-bunded plots for soil fertility, depth of soil, and plowing, showed little difference between them, suggesting the bunds are not increasing returns to these endowments. *Fanya juu* "neither increased yields nor complemented other inputs. It is therefore hard to argue that they represent a 'win-win' solution to the problem of soil erosion" (Kassie et al 2008:15). Further, farmers voiced serious objections to the bunds, complaining of water logging and loss of cultivable area by 8-20%; the narrow terraces also made turning ox-drawn plows difficult – a complaint recorded by other researchers (e.g., Bewket 2007). The water logging may be because Anjene is a relatively high rainfall area (1690mm) — substantially above the recommendation for *fanya juu*. Some years previously, Shiferaw & Holden (2001) had also used data from Anjene and Andit Tid (another SCRP site) to study the farm-level private incentives to invest in SWC measures (including level and graded bunds and level and graded *fanya juu* as well as grass strips), and found the incentives to invest very low except low cost methods such as grass strips in Anjene. The yield penalty from area loss combined with high investment costs contributed to this.

Other studies have also found farmers rejecting *fanya juu*. In Chemoga watershed, aside from most farmers' claiming they participated in the SWC program against their will, Bewket & Sterk (2002)

found 60% of farmers believed they had made erosion worse, largely through structural failure: the structure collects too much water which spills down slope at its weakest point and through a chain process other bunds break. On the other hand, in a nearby watershed (Dilgil), Bewket (2007) found that *fanya juu* were combined with other interventions such as stone and soil bunds, cut-off drains and agro forestry, and *fanya juu* were actually the most preferred structures. The reason given is they take up less space than soil bunds and transform into bench terraces more quickly. Bewket (2007) notes that unlike the Chemoga case, *fanya juu* were not presented as the only conservation practice; rather they were integrated with other measures. Labor shortage was however identified by farmers as a major problem with regard to implementing and maintaining SWC technologies, in contrast with Chemoga. Even with their positive views of *fanya juu* and other SWC interventions, however, many farmers felt they were not suitable to their needs and farming system, the designs were too difficult to replicate and maintain themselves, they were too land-consuming and labor-consuming to maintain, tenure insecurity was a disincentive, and finally, despite claims by officials that the intervention strategy was participatory, farmers viewed it otherwise. Farmers claimed "participation" meant largely being "persuaded" by officials and influential farmers to participate (Bewket 2007)[48]. These factors taken together raise questions about the long term sustainability of the introduced measures.

Stone and soil bunds

Assessments of stone and soil bunds, and "stone-faced trench bunds" are equally mixed. Some studies find very positive outcomes in terms of reduction of run-off and erosion, grain yields, and benefit-cost ratios. For example Nyssen et al (2007) conclude that from technical, ecological and economic points of view, stone bunds in Tigray have very positive outcomes, and 75% of farmers are in favor of them on their land. The authors discount the often-mentioned rodent problem as being not specific to stone bunds (farmers may have a different view; see e.g., Aklilyu Amsalu & de Graaf 2006; Bewket 2007). On plots with stone bunds of different ages (3-21 years) grain yields are higher even after accounting for the reduced area, while the value of the incremental increase in yield is almost equal to the cost of construction per ha. On the other hand, Kassie et al (2007), based on a sample survey of over 900 households in Tigray and Amhara, come to a more nuanced conclusion. They find that plots with stone bunds are consistently more productive than those without such measures in semi-arid areas but not in higher rainfall areas. Moisture conservation is, not surprisingly, more productive in low rainfall areas than high rainfall areas of Ethiopia, where it may lead to water logging and other problems. In higher rainfall areas other conservation measures, such as drainage ditches, are more appropriate. This finding is consistent with other studies; for example Pender and Gebremedhin (2006) found in Tigray that the estimated average return on stone terraces was 46%, a result of a predicted 23% increase in crop yields. Stone terraces increase the benefit of fertilizer, leading to more adoption of fertilizer on plots with terraces (opposite the finding reported above in subsection 7.1 by Yesuf and Köhlin 2009).

Concluding remarks on bunds

This section cannot do justice to the wide range of technologies subsumed under the term "bund" and the decades of experiences in Ethiopia and elsewhere. Experimental plot research on the technical performance of bunds, i.e., impact on soil loss and run-off, demonstrates their positive

[48] The second author of this report chaired the evaluation of SCRP; that team found the same issues expressed by farmers in Andit Tid and Maybar research sites.

impacts compared to the control (for example, see Mitiku et al 2006:144-146 for a summary of SCRP results). Nevertheless, it is clear that as with RWH ponds, actual field experience has been very mixed, with some cases of positive outcomes reported and many others where farmers' perspectives remain skeptical or negative towards the introduced practices. It appears that there are numerous cases of inappropriate designs being imposed, for example, *fanya juu* in high rainfall areas. As with other interventions, top-down implementation, with participation involving at best "consultation" rather than supporting communities to develop their own land and water management plans, has been a major drawback. Disappointing results and perceptions that the structures do more harm than good (e.g., increasing erosion, removing too much land from production) or do not fit their needs have led farmers to remove the bunds in many places. Including various types of bunds in a repertoire of options to reduce land degradation and improve water management, along with bio-physical, agro forestry and more appropriate land preparation makes far more sense. A policy framework supporting implementation strategies that provide positive incentives for farmers to adopt and continue to use SWC-RWM practices are the most critical requirements for success. With so much research demonstrating low or negative returns, however, it is no surprise that there is little spontaneous scaling out; but one wonders why government persists in blanket promotion of these technologies.

Resource-conserving agriculture

The term "resource-conserving agriculture" covers a wide range of farming systems that seek to conserve natural resources and minimize negative environmental impacts. Bossio et al (2007:571, Box 15.6) include in this category organic farming, integrated pest management, integrated nutrient management, aquaculture, and other practices not reviewed here. They also include three promising practices we do review: conservation agriculture (especially reduced or zero-tillage), agro forestry, and integrated livestock management. Pretty et al (2006) review the global evidence showing substantial improvements in crop productivity while also improving the supply of environmental services from adopting these kinds of technologies.

Conservation agriculture practices

"Conservation agriculture" refers to non-inversion land preparation methods, i.e. replacing conventional plowing with zero tillage, reduced tillage, ripping and sub-soiling, usually combined with mulching. It is widely practiced in the USA and Latin America, and is increasing rapidly in Asia and to a lesser degree SSA (Rockström et al 2009). It has numerous advantages: it reduces energy requirements for land preparation; it reduces soil erosion induced by inversion plowing; in arid and semi-arid areas, it conserves water; and a growing number of studies demonstrate it can lead to major improvements in yield and water productivity in rainfed systems (Rockström et al 2009 review the worldwide including SSA evidence for this). Conservation agriculture poses challenges as well: high initial costs of special planting equipment, weed control especially in its early phases, and the need for a new mindset and new management skills. Though conservation agriculture is not widely practiced as yet in the Ethiopian Highlands, there is growing interest at least among researchers in the potential benefits of reduced or zero tillage cultivation. This subsection reviews some of the literature. Some agro-pastoral communities practice it by using sticks to make holes, drop 5-10 seeds per hole, and covering the holes without any disturbance to the land; this suggests the idea is not entirely new.

An increasing number of studies demonstrate the technical advantages of conservation agriculture based on non-inversion tillage, not only in sub-humid and humid regions where it originated, but in arid and semi-arid areas including Ethiopia. Rockström et al (2009) report results from on-farm farmer- and researcher-managed experiments in Kenya, Tanzania, Zambia and Ethiopia. In the Ethiopia experiments, neither improved tillage (ripping with ridging) alone nor conventional tillage with fertilizer improved maize yields; but combining improved tillage with fertilizer led to significantly higher yields. For teff, conservation tillage with no fertilizer increased yields by 20-50% compared to conventional tillage, but adding fertilizer led to even higher yields[49]. This is important because traditional land preparation for teff involves six plowings, making the soil especially vulnerable to erosion.

Regionally, the results demonstrate major gains in the productivity of rainwater: non-inversion tillage is thus an effective strategy for *in situ* moisture conservation. McHugh et al (2007) report experiences with sub-soiling, zero tillage, and open and tied ridges compared to conventional tillage in Amhara. Their results were more mixed than those reported by Rockström et al (2009): their efficacy varied depending on the timing and intensity of rainfall. Overall, they suggest that on slopes less than 8%, oxen-drawn ridge tillage and to a lesser degree sub-soiling can mitigate the impact of short dry spells, especially during seasons with fewer intensive rainfall events. Araya & Stroosnijder (2010) report that on an experimental station in Tigray, barley yield and rainwater use efficiency increased significantly with tied ridges (but not mulch) during below-average rainfall years; there was no difference from the control group when seasonal rainfall was above average.

Temesgen et al (2009) tested several alternative-design implements that are modifications of the traditional *maresha* plow. They also found that reduced tillage resulted in higher teff yields, but not maize, whose yield was reduced by loss of moisture through ripping (ripping apparently enabled teff roots to go deeper than they otherwise would). Gebreegziabher et al (2009) got good results in Tigray from permanent raised beds with contour furrows: runoff and soil loss were reduced, though yields were not improved. In vertisol soils, the use of the broad bed maker plow has also led to reduced soil erosion and higher yields (Rutherford 2008). Finally, introduction of a modified version of the *maresh*a plow (known as "*Tenkara Kend*") by the food security program of GTZ in South Gondor was found to cultivate much deeper than the scratching of the traditional *maresha*; the result was fewer plowings and higher crop yields. The *Tenkara Kend* might have helped break the plow pans created by the years, even centuries, of continuous scratching of the surface 5-7 cm with the *maresha* and hence, contributed to better aeration, soil moisture storage and penetration by crop roots of greater depths (based on personal knowledge of second author).

We have found only one economic analysis of the returns on reduced tillage; and no studies on farmers' views. Kassie et al (2009b) compared the productivity gains (profitability and yields) of reduced tillage compared to chemical fertilizer in low- and high-rainfall agro-ecologies in Tigray and Amhara. They found that reduced tillage is clearly superior to chemical fertilizers in low-rainfall areas; but in high rainfall areas, not only is fertilizer "overwhelmingly superior," but reduced tillage could result in productivity losses; weeds are the major problem in this context (T Amede, personal communication). Though less conclusive because of sampling issues the study suggests combining reduced tillage and use of fertilizer leads to better yields. The authors conclude that adoption of

[49] This may work for teff only if herbicides are used (T Amede, personal communication).

reduced tillage could be win-win for poor farmers in dry areas: it can reduce production costs, obtain environmental benefits, while also getting higher yields.

Aune et al (2006) report results from research on reduced and zero tillage in Tigray, Amhara and Oromiya. They claim reduced tillage combined with herbicides to control weeds led to far higher yields of maize, and with reduced labor and oxen requirements, higher returns. However, farmers discontinued the practice because of the high price of herbicides, low price of maize, access to oxen without payment (so it is not perceived as a cost), and low opportunity cost of labor. Pender & Gebremedhin (2006) also report significantly higher yields in Tigray from reduced tillage. The results reported by Aune et al (2006) are inconclusive; their study is motivated by a search for alternatives to ox tillage. Currently, oxen rental and sharecropping are costly; grazing oxen contributes to degradation of rangeland; and oxen consume fodder that could be used for more productive dairy cows. Further, the need to use oxen to till the land puts female-headed households at a disadvantage because of the cost of renting and cultural limits on women plowing. In other words they argue that changing the composition of the livestock population can greatly improve productivity of mixed crop-livestock systems; and reduced or zero tillage would enable such a change.

Livestock management for water productivity

In the mixed crop-livestock farming systems of the Ethiopian Highlands, livestock, especially cattle, are critical system components (Herrero et al 2010). They provide essential services such as traction and manure (recycled as valuable soil nutrients or as a source of energy for cooking and heating). Livestock products – milk, meat, hides – are an important source of income and livestock also constitute a 'bank account' – an asset that can be converted to cash when needed. Demand for livestock products is growing rapidly in most developing countries, including Ethiopia, suggesting there are substantial benefits to be gained from investing in improving livestock productivity. However, there is currently a very large gap between the potential benefits farmers can obtain from keeping livestock and what they actually receive; productivity is low, and market channels poorly developed. Further, livestock management is implicated as a major cause of land and water degradation, through over-grazing that reduces vegetation and damages fragile soils leading to erosion, as well as pollution of water bodies[50]. This is especially the case in high density areas such as the Ethiopian Highlands, where diminishing common grazing areas are degraded by overstocking. Tegegne et al (2009), in a study of transhumance in North Gondor (Amhara), record that most of their respondents estimate transhumance is increasing because of feed shortage, expansion of crop cultivation into previous grazing areas, and rising human and cattle population.

While the importance of livestock in the farming systems of Ethiopia has been recognized for a long time, their role in reducing or increasing the productivity of water has only recently been recognized. Collaborative research led by ILRI with IWMI and other partners has demonstrated the importance of "livestock water productivity" (LWP) in both reducing degradation and enhancing sustainable and productive farming systems (for example Peden et al 2007). Research carried out in the Nile Basin during phase 1 of the CPWF and with BMZ support has made major contributions to understanding LWP and the potential pathways for improving it. This subsection highlights a few observations relevant for phase 2.

[50] Descheemaeker et al 2009a, 2010 provide a good synthesis of these and other points.

In section 2 we noted that measuring "WP" is not straightforward. *Livestock* water productivity is even more complex and multi-dimensional. LWP is defined as the ratio of beneficial outputs and services of livestock to the water depleted in their production. While it is clear that livestock-containing farming systems offer substantial scope for increasing total water productivity, there is also a need to improve our capacity to analyze water consumption and productivity in such systems; doing so will unlock potential for systemic improvement that is currently not well understood (Cook et al 2009). But understanding the multiple interactions occurring within mixed crop-livestock systems, and the flows and roles of water, at diverse scales from farm to river basin, is immensely complex, as Figure 2, based on a water accounting framework, illustrates.

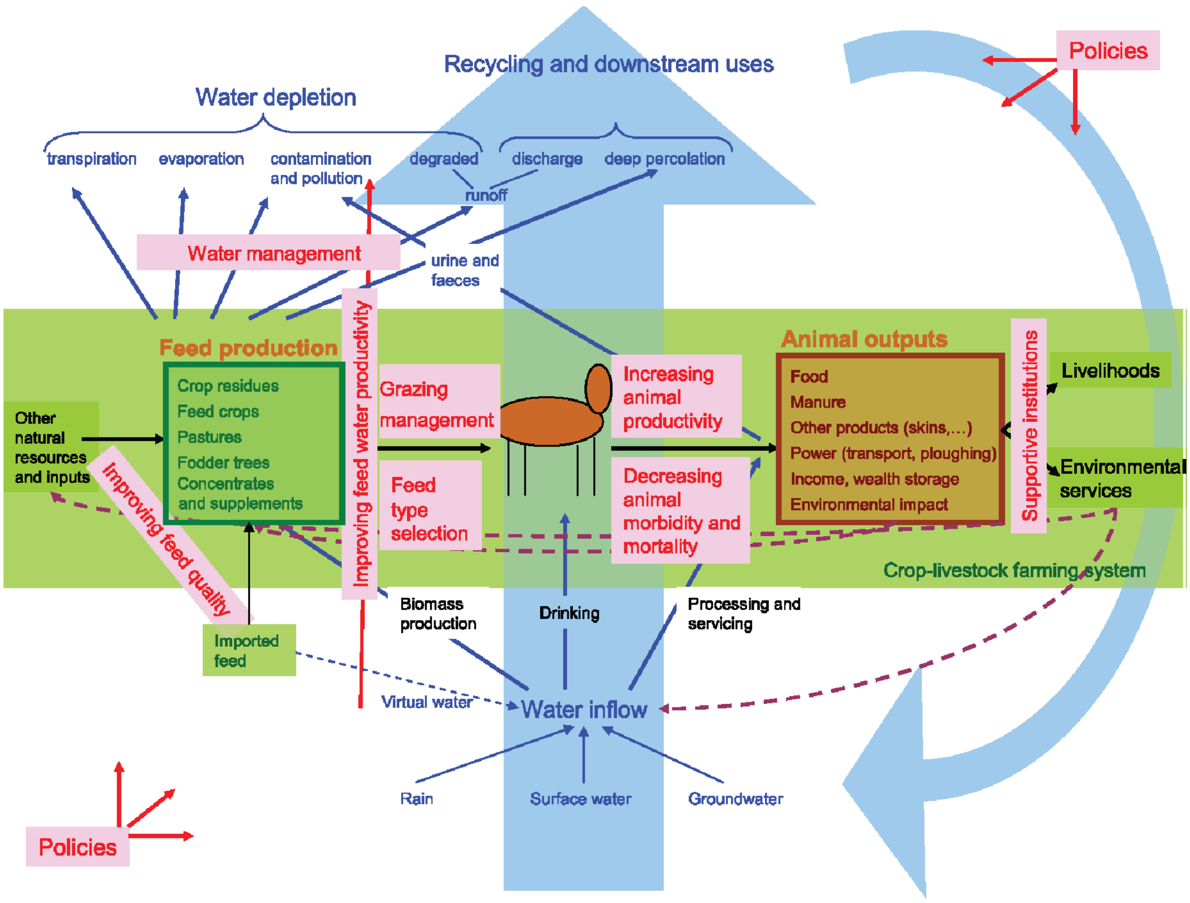

Figure 2. The livestock water productivity framework for mixed crop-livestock farming systems
Note: The horizontal area represents the livestock component of crop-livestock farming systems. Vertical arrows indicate the different water inflows and outflows constituting the water balance. Dashed arrows indicate feedback loops, such as the use of animal outputs for feed production or the impact of livestock on environmental services. Technical strategies that could improve LWP are located on the interface between the crop-livestock production system and the water balance (text boxes highlighted in pink). Strategies involving policies and extension and capacity are located at the outer boundaries (text boxes highlighted in pink), illustrating that they potentially influence all flows and interactions. *Source:* Descheemaeker et al 2009a: Figure 1. Descheemaeker et al (2010:581, Figure 1) provides a simpler version of this figure.

Research carried out with BMZ support and then under CPWF Project 37 (Peden et al 2008, 2009) has made important contributions to achieving a better understanding of LWP in the Blue Nile basin,

and identifying potential entry points and intervention strategies. The largest quantity of water consumed by livestock is that required for growing their feed; drinking water needs to be of high quality but volumes are relatively low. CPWF Project 37 field research in the Gumera watershed of the Abay Basin has examined LWP and crop water productivity (CWP) in three farming systems: barley-based (at cool high altitudes), millet-based, and rice-based (at hotter lower altitudes) (Haileslassie et al 2009a, b). Within each system sample households were classified into three wealth groups (rich, medium, poor) using participatory wealth ranking techniques. Data on WP were collected through focused group discussions, field observations and secondary data. Mean gross LWP for all systems was substantially higher than for crops ($0.42/m^3 LWP versus $0.29/m^3 for CWP); but there was considerable variation across farming systems. LWP was highest in barley-based systems ($0.69/m^3) followed by millet- and rice-based systems ($0.45/m^3 and $0.15/m^3 respectively); CWP ranged from $0.40/m^3 in the rice-based systems to $0.33/m^3 and $0.26/m^3 respectively in the millet- and barley-based systems. Net LWP and CWP showed similar trends (Haileslassie et al 2009b:5, Table 4). The range of LWP was even greater among wealth groups ($0.10/m^3 to $0.60/m^3 per year) than among farming systems with the poorest people achieving the lowest productivity (Haileslassie et al 2009a).

But this is not the end of the story: LWP is a function of many influences, including crop water productivity itself. LWP can be enhanced by using crop residues; but the LWP productivity contribution of these residues may be low if their nutrient value is low. Some indigenous grass species are high in nutritional value but are less water productive and are degrading because of overstocking and inappropriate management. Farmers' strategies in terms of their mix of crops and livestock also proved complex: barley-based systems use little water, giving a high WP; but the market values of these crops is low, giving low WP economic returns – forcing farmers to keep livestock at higher densities for income (Haileslassie et al 2009a). Further, how productivity is expressed gives different results: herd productivity measured as US$/Tropical Livestock Unit (TLU)/year was *lower* in the barley-potato system compared to the other two, a function of density, herd structure and multiple uses. Expressed in US$/ha/year, livestock productivity in the barley-based systems were substantially higher than in the teff-millet and rice systems. Differences among wealth classes were remarkable as well: the medium and poor households had higher livestock productivity per TLU, but the rich had higher productivity measured per ha (Haileslassie et al 2009b). These findings demonstrate the complexity of these farming systems and the need to tailor interventions to local conditions. They also suggest that interventions to improve LWP may not improve productivity and returns to farmers in all circumstances – much will depend on their priorities, the relative scarcity of resources, and market opportunities.

Unlike the case for RWH and SWC technologies, there are no cases available of interventions designed to improve LWP *per se* in Ethiopia, and therefore no research documenting outcomes (ILRI can point to numerous cases of improvement in livestock management and productivity from more traditional perspectives). The CPWF 37 researchers have however proposed innovations that would likely lead to improvements in livestock productivity from a water management perspective. LWP can be increased by either raising the efficiency of water-based inputs, or increasing the quantity and quality of livestock outputs; but because innovation is a social process, improving LWP must be approached in an integrated and interdisciplinary manner (Amede et al 2009c). Peden et al (2008) discuss four major strategies for increasing LWP: providing feeds with high CWP; making better use of marketing and animal sciences (genetics, health services, nutrition); adopting animal management

practices that reduce negative impacts on the environment; and spatial allocation of watering points to balance supply and demand for water and feed. Descheemaeker et al (2009a, 2010) propose a framework distinguishing two spheres and therefore entry points, the biophysical and the social-political-economic. These interventions are not mutually exclusive but interact differently at different scales. Their paper focuses largely on three groups of biophysical interventions: feed, water, and animal management; but also identifies gaps in both policies and institutional arrangements that would encourage and facilitate achieving higher LWP. Amede et al (2009b) discuss a participatory action approach to improving LWP based on previous project experiences; but acknowledge scaling adoption of innovations out to a wider scale remains a challenge. Amede et al (2009b, c) build on this to propose a three-component conceptual framework derived from innovation systems literature, and illustrate it with cases from Kenya, Tanzania and Zimbabwe. The three components are similar to those of Descheemaeker et al (2009a, 2010): technologies, institutions and policies. Importantly, they draw attention to the critical importance of local political relationships where people have conflicting values, goals and power. The ultimate goal of improving LWP is improving the livelihoods of poor people, making it critical to approach LWP interventions from a gender perspective. Interventions should not undermine women's already precarious situation, and where possible they should strengthen women's roles – an approach that potentially leads to greater benefits. For example, a shift from males herding cattle for grazing to stall-feeding may add to women's work load if they are charged with gathering fodder. Gender issues are discussed further below in section 8.

None of the LWP literature to date has examined the potential benefits of focusing on alternative livestock, for example goats and poultry. These are likely to have higher water productivities, and are more likely to be managed by women for their own benefit. Further, it is critical to maintain a focus on the agro-ecological system, and the watershed landscape as an integrated system. Single-factor interventions, whether they be SWC structures, RWH practices, or improved livestock management, may not lead to optimum outcomes. This is discussed further below (section 9).

Agro forestry

Agro forestry is a broad term covering the integration of woody vegetation (trees, legumes) and grasses into a mixed cropping system. It is a critical component of the mixed crop-livestock farming systems of the East African Highlands, including Ethiopia. Diverse tree products are largely multi-purpose: they produce fruit, fodder, medicine, fuel, and timber, and are a source of income. Woody legumes contribute to increased soil fertility through nitrogen-fixing and composting, while also providing human food and animal fodder. In recent decades, farmers have come to recognize the value of fast-growing exotics such as Eucalyptus, whose timber has a ready market; but there are serious trade-offs because of the apparent reduction in groundwater and therefore springs and shallow wells that is associated with this species (e.g., German et al 2006)[51]. On the other hand, integrating fodder and other species into farms can lead to improved productivity and incomes; it can contribute to maintaining soil fertility, and certain grasses and trees can either by themselves or in association with physical structures, contribute to soil and water conservation (see for example Hadgu et al 2009 on the positive impacts of *F. albida* trees on crop yield and soil fertility in Tigray).

[51] Nevertheless, in a personal communication T Amede reports results from a study showing eucalyptus WP is 10-20 times that of maize over a 20-year period. We do not have access to this study.

Further, agro forestry is one component of means to improve the value of common grazing lands and community wood lots (discussed in the next subsection).

Assisting farmers to integrate new and improved agro forestry products into their farming systems requires a participatory approach, building on farmers' own perspectives and priorities (German et al 2006; Bekele-Tesemma 1997). Bekele-Tesemma (1997) describes in detail the application of a six-step participatory approach to introducing agro forestry and other SWC innovations at a study site in Amhara (*Weyna Daga* zone). Eleven agro forestry and SWC intervention categories are defined, and the lessons learned from the experience identified. The author argues that whereas past FfW SWC programs have been counter-productive, his approach building on indigenous practices has had very positive impacts.

Common, often even open-access, rangelands and pastures tend to be located on marginal or fragile land, not suitable for crop production; and inappropriate grazing practices lead to their degradation (Alemayehu et al 2008). Integrating fodder trees along with other multiple use trees within agro forestry-based systems, combined with improved community management, can stabilize the land, reduce erosion, improve fertility and increase ecosystem stability. Although very little is known about the water productivity of most forage crops, adding these nutritious fodders to animal products does improve animal productivity. Some grasses (e.g., Napier or elephant grass, vetiver) are fast growing and dual purpose: they provide fodder while also stabilizing land and gullies (though elephant grass may compete with adjacent crops for water) (Descheemaeker et al 2009a; see also Wubshet 2004 and SLUF 2008b for vetiver grass). The benefits of many agro forestry practices have been demonstrated many times; but we conclude that agro forestry innovations need more exploration from an integrated RWM and landscape perspective.

Protection of common land and collective action on micro-watersheds

Ethiopian Highland communities depend on common property resources for their livelihoods. They are a source of firewood, construction material, and fodder for livestock; and are often located in the watershed for common water resources (springs, small reservoirs). In most areas, there is now a severe shortage of food, fodder, firewood and timber, placing great pressure on resources. There is a long tradition of community management of these resources as well, though the details vary among different communities and regions. Indigenous institutions such as the *Quero* system were undermined by the radical reforms combined with top-down interventions during the *Derg* period; however in many communities they continue in some form, often modified (e.g., inclusion of previously marginalized groups) (Ashenafi & Leader-Williams 2005). Their effectiveness varies considerably; for example Tesfay (2006) documents that there is considerable under-contribution to the traditional voluntary labor for management of commons in the Tigray villages he studied; 14-24% of the sample households fail to contribute at all. As discussed in section 4, above, Gebremedhin et al (2006) found village management of common grazing land and woodlots to be more effective than *kebele* management in Tigray. Several bilateral-funded donor projects, including SARDP and AMAREW in Amhara, have sought to promote community empowerment and management of commons; and community empowerment has become a goal as well as means to promote SWC of the MERET and other government programs (e.g., Liu et al 2008; Cohen et al 2008). Liu et al (2008) report on "a series of small short term successes" by AMAREW in promoting "community watershed management organizations" (CWMOs) in two pilot watersheds in Amhara. The study illustrates both the potential benefits and the daunting challenges for such programs.

There are also case studies of NGO experiences with community management of resources (SLUF 2008a, b).

The MERET Project and its predecessors have promoted the establishment of “Area Enclosures” (AEs) or “exclosures” as a means to reverse land degradation. AEs involve exclusion of human and livestock interference – or in practice, restricted interference – to allow regeneration (Nedessa et al 2005). Descheemaeker et al (2009b) report on the impacts on water availability and biomass of establishing such exclosures in a semi-arid highland area of Tigray with steep slopes (35-70%). Basically they found that in the protected areas, vegetation regeneration leads to increased infiltration of water that recharges groundwater and springs, and to higher transpiration, and therefore a more productive use of water for biomass production. This in turn contributes to increasing LWP.

However, a paper by the manager of MERET and others (Nedessa et al 2005) reports on the complexities involved in promoting community-managed AEs. While increased biomass is a [52]convincing benefit, complete long term exclosure may result in lower biodiversity; controlled grazing by multiple species may be a better option. While biodiversity conservation and regeneration was the original motivation in promoting AEs, for local communities economic returns have the highest priority. Promoting community management becomes the key intervention and remains a serious challenge. Enforceable community (*serit*) laws are considered crucial to successful management of common property resources, but Nedessa et al (2005:11, 22-23) claim they do not match current demands and needs, and are seen by many as simply “penalizing tools.” *Serit* rules often favor those with resources such as cattle and marginalize the poorest households. To be effective, they need an institutional framework to coordinate overall implementation, and local-level institutions need to be reformed, replacing male- and elite-based power structures[53]. The appointment and remuneration of AE guards is another issue. Government pays temporarily in some cases, though this is not sustainable; communities are often not prepared to take over this function and where guards are only part-time or non-existent, people take advantage. Finally, communities are grappling with how to share the regenerated resources or income from these commons.

Conclusion

Unfortunately, there has been little systematic comparative research evaluating the outcomes and impacts of the full range of SWC-RWM interventions, or of the interactions among them; and no such research taking a landscape or integrated watershed perspective. There are two partial exceptions regarding the paucity of comparative research. One is a study of the poverty impacts of *in situ* and *ex situ* AWM technologies based on a survey of 1517 households in 29 PAs in four regional states (Amhara, Oromiya, SNNPR, Tigray) (Awulachew et al 2009). The study focused on six categories of AMW technologies: RWH ponds, shallow wells, deep wells, river diversion, micro-dams and “other” (not defined), and compared households using these to non-user households. They found highly significant differences in agricultural incomes ($p<0.0001$): those with AWM technologies used more farm inputs and were more active participants in the market. Using an absolute poverty line of ETB 1821 (household consumption per adult equivalent per year;

[52] Seeding may be a way to address this (T Amede, personal communication).

[53] For example, “farmer representatives” at local levels in Tigray are often members of the ruling party with political ambitions (Segers et al 2008b).

approximately $200), about 48% of AWM users were poor – but 62% of non-users were poor, a significant difference. Perhaps most surprisingly, all the *ex situ* AWM technologies were poverty-reducing, especially deep wells, river diversions and micro-dams. However, those using *in situ* technologies (terraces and soil bunds) had higher poverty levels in terms of incidence, poverty gap and severity. They speculate this is because the *in situ* technologies were "only soil conservation (erosion reduction) measures with little immediate impact on productivity growth" and they may divert labor from direct production to conservation (Awulachew et al 2009:255). From the contents of the paper, it is not possible to identify the direction of causation: it is possible that relatively better-off households have access to more productive AWM technologies and other productivity-enhancing inputs (indeed this seems implicit in the findings).

The other partial exception is a study of impacts of different SWC technologies on crop production and risk-reduction across different rainfall areas and Regions of the Ethiopian Nile Basin (Kato et al 2009). Using a household and plot-level data set and controlling for some household and plot-level factors, they found that soil bunds, stone bunds, grass strips, waterways and contours all have significant positive impacts on average crop yields in low-rainfall areas (but surprisingly only soil bunds have a significant risk-reducing impact); however only soil bunds have significant risk reducing impacts in low agricultural potential areas; and only waterways and trees have significant positive impacts on yields in high-rainfall areas (but most SWC have a significant risk-reducing effect). Within low-rainfall areas, they found considerable spatial heterogeneity by Region. In Tigray the most common SWC investments were soil and stone bunds; in Amhara waterways and stone bunds; in Oromiya soil bunds and waterways; in Benilshangul-Gumuz waterways; and in SNNPR trees. Low-rainfall areas have more stone and soil bunds than in high-rainfall areas, the latter more waterways and irrigation. But within both high- and low-rainfall areas the impacts of different SWC technologies on risk were highly diverse, making generalization impossible.

The findings of Awulachew et al (2009) and to some degree Kato et al (2009) contradict the results of some but not all the other studies reviewed above regarding the impacts of bunds and terraces; and their results are also not entirely consistent with each other. Indeed the mixed and even contradictory results in terms of economic and ecological impacts, risk-reduction, and farmer acceptance and use of RWM-SWC interventions is a major finding of this review. Although scientists can identify those technologies most likely to be effective under given conditions, they cannot guarantee success.

Nearly all the reviewed research focuses on maximizing outcomes of specific interventions, for example ponds for household water use, or terraces to reduce erosion. This is also the case for major past research projects such as SCRP, policy research on resource management, conservation agriculture, agro forestry and livestock water productivity. Although some research (especially the work on LWP and upstream-downstream interactions) does take a "systems" perspective, the focus remains on maximizing outputs of a single element of the system. We suggest that it is time for a paradigm shift to system optimization (German 2006) in an innovation system participatory research-for-development framework combined with an integrated landscape perspective (see below, section 9). Finally, it is clearly critical to balance short and long term goals. In principle, farmers share the longer term goals of resource conservation driving SLM and other programs, but as is now recognized, they heavily discount long-term goals because meeting short term consumption goals is such a challenge.

8. Targeting Rainwater Management Interventions

This section discusses targeting of RWM interventions in terms of three dimensions: gender and poverty, agro-ecological zones, and "development domains." Development domains combine agro-ecological, market access, and population density variables. We also discuss government plans regarding targeting of its new SLM program.

8.1 Gender: Targeting poor women as well as men

The Ethiopian Constitution guarantees equal opportunities for women and men, and official documents such as PASDEP emphasize the critical importance of effectively targeting women for both equity and practical reasons. The federal government has established a Ministry of Women's Affairs to promote gender-mainstreaming and the regional governments have also established Women's Bureaus. A special parliamentary group oversees gender-mainstreaming policies as well. But traditional Highland society remains a male-dominated socio-economic system buttressed by strong cultural norms at household, village and higher levels. Applying van Koppen's (2002) "gender performance indicator," rural Highland Ethiopia is classified as a "male farming system:" in most farms, women are unpaid family workers; women who manage their own farms are disadvantaged in terms of access to resources, having a voice in decision-making forums, and even by a still-strong cultural taboo against women plowing. Government officials – change agents such as DAs – are more often male, bringing further bias in actual service delivery even if rhetorically women are considered important clients. Interventions such as irrigation, RWH ponds, and measures to improve livestock management, have differential and sometimes unintended consequences for women: often negatively by increasing their workloads; but in some cases positively by enabling them to produce more vegetables for home consumption or milk for sale. In this context, and given the critical importance of gender as an organizing principle of all societies, it is surprising how few researchers have worked on gender and power relations, how these vary and work out in practice, and what kinds of approaches might be most effective in terms of empowering women with the means to improve their lives.

At the macro level, there is evidence for significant improvements in gender equality in some areas, especially access to primary education, though with large regional and rural-urban disparities. Development indicators for female-headed households are also highly heterogeneous: in general female-headed households are not necessarily poorer than other households or women in male-headed households (a function of the broadly shared poverty of rural Ethiopia); but they are far more vulnerable to shocks, showing large fluctuations in welfare from year to year. They have fewer livelihood options as a result of the gendered division of labor, further limited by low skill levels and onerous household management responsibilities. In rural areas they face more binding constraints than men, for example in workloads and access to water, credit and perhaps most significant, land (despite government efforts). Nevertheless, targeted government support programs are having a positive impact. For example both spouses' names are included in new land certificates, micro-finance institutions are extending credit to women, and there are quotas for training women DAs. The real impact of such programs takes time to perceive. Macro-level economic modeling demonstrates very high levels of benefit in terms of GDP growth from more effective targeting of women (World Bank 2009).

Over a decade ago, a USAID-supported analyst (Frank 1999) assessed the roles of women in rural Amhara, the "contested identity" of women farmers, and the structural barriers augmented by local

culture that precluded women from participating in agricultural extension services and getting access to land, technology and decision-making power. Ethiopian agriculture is extremely labor-intensive, and women play critical roles in nearly every stage of the productive process (except plowing with oxen, though even this is beginning to change in some places). They are also responsible for the household vegetable garden and often for livestock management; estimates suggest they work twice the hours per day as men. Women are responsible for fetching household water, often from long distances. Some of the biases against women may have weakened since that time, but they remain salient, as demonstrated by a recent report on SARDP's attempts to address gender inequality in Amhara.

Farnworth & Gutema (2010) report that although gender mainstreaming is government policy, the MoARD has no gender strategy, though the Amhara Regional government had recently prepared one. Gender focal points are being created in government units at different levels, but they are "low in the hierarchy" and unable to influence programs. Despite good intentions and some demonstrably good results especially in land titling, even SARDP never developed a gender strategy, and had no system for monitoring progress on the gender dimensions of its program. SARDP introduced several institutional gender innovations at local levels, for example "gender analysis groups" and "women's forums," but their sustainability is doubtful. Gender training does not appear to have changed mindsets of male officials. SARDP like other programs was hampered by the lack of analysis of gender relationships at rural level. The report suggests more effective and specific accountability for gender impacts is needed, supported by a reliable M&E system; and innovative approaches such as "women-friendly value chains" could be helpful.

There is some research on intra-household control of assets, though it is not specific to RWM interventions. Fafchamps & Quisumbing (2001), using detailed household data from the 1997 Ethiopian Household Rural Survey, show that control over productive resources is in the hands of the household head, irrespective of ownership at or after marriage (i.e., a male head of household gains control over assets brought in by his spouse). A recent, more nuanced study using a subsample from the Ethiopia Demographic Health Survey of 2005 has shown the strong influence of highly unequal gender norms mediated by local ethnic-gendered institutions on the bargaining power of women in households – even where women have an education, income, assets or exit power that should empower them (Masbout & Staveren 2010). In spite of radical improvements in formal institutions regarding women's rights in all spheres of life, low levels of awareness of these rights, strong cultural attitudes for example toward violence against women, conspire with gender-unequal social norms, cultural beliefs, and traditional practices to reduce women's decision-making power. The policy conclusion drawn by the authors is a need to shift from exclusively individual-level women's empowerment to focusing on the institutional level where group norms are very unequal. How to operationalize this is not discussed. Many development programs, including the LLUPAs for planning IWM in small watersheds and WUAs for managing SSIs improved with government support, mandate including women representatives; but inclusion alone does not necessarily lead to empowerment and proportional benefits. Liu et al (2008), reporting on AMAREW Project experience in two watersheds in Amhara, claim that CWMOs in each village cluster were required to have four women and four men as leaders; and "after some initial opposition it has become acknowledged that the 50% rule resulted in a stronger organization" (page 16) –but it is not clear exactly who has acknowledged this or what it means. More innovative institutional alternatives need to be explored in Ethiopia.

Unfortunately, very little of the research on RWM in Ethiopia, even that carried out under the CPWF, has addressed gender issues in detail. A partial exception is the BMZ- and CPWF-supported projects on livestock water productivity[54]. Mapedza et al (2008) summarize reflections on 'why gender matters' emerging from the LWP Project. Technological innovations are rarely gender-neutral; they nearly always have implications for labor requirements and access to or control of benefits. Therefore, just improving LWP *per se* is not sufficient. For example, they note that since smaller livestock such as chickens and goats are usually controlled by and largely benefit women, they offer more opportunities than large livestock for women to benefit directly. On the other hand, if better forages result in reduced time women need to harvest, clearly they benefit. In one watershed in Eastern Ethiopia, where milking livestock is women's responsibility and is one of the few sources of cash income for them, improved water supply led to higher productivity. Women therefore produced more milk from fewer cows, increasing their income while reducing their labor. Clearly, the action research to be done under CPWF phase 2 must focus more attention on the gender dimensions of RWH.

Finally, there is little research on the poverty impacts of RWM. The study by Awulachew et al (2009) is an exception, but the causal relationships are not clear. More research is urgently needed on this topic, but more nuanced in terms of target groups, agro-ecological zones and development domains. Awualachew et al (2005) suggested the idea of classifying and identifying target groups based on their assets and livelihoods, aiming low-cost low-maintenance technologies to the poorest. We conclude by repeating that technological innovations are rarely gender-neutral; indeed technologies are socially constructed and embedded and nearly always have unanticipated social and economic impacts.

8.2 Targeting by agro-ecological zones and 'development domains'

Agro-ecological zones

The official rural and agricultural development strategy, reflected in PASDEP, divides the country into three main agro-ecological zones in terms of rainfall, land type, altitude and other attributes and tailors strategies to the conditions in each zone. The three zones are high rainfall areas, moisture-stressed areas, and pastoral areas (MoFED 2006a). They are often referred to as the "Three Ethiopias." This is complemented by more detailed agro-ecological zoning into a set of 18 major and 42 minor agro-ecological zones based largely on temperature and moisture regimes. A more traditional and still-used agro-ecological or farming system classification system is based on altitude, further sub-divided by temperature and rainfall (see CSA et al 2006:16-17). These are, from lowest and hottest to the highest and coldest altitudes: *Bereha* (<500 masl), *Kolla* (500-1500 masl), *Woina Dega* (1500-2300 masl), *Dega* (2300-3200 masl), *Wurch* (3200-3700 masl), and *Kur* (>3700 masl). These are further subdivided based on average annual rainfall into dry (<900 mm/year), moist (900-1400 mm), and wet (>1400 mm). Figure 3 is a map of the dominant farming systems in the Ethiopian portion of the Abay Basin. It is clear that most of the highland is dominated by teff and wheat areas, corresponding to moist or wet *Wurch, Dega* and *Woina Dega*.

[54] Gender was an important focus of the CPWF-supported MUS Project as well, but we have not found research results from that project in Ethiopia.

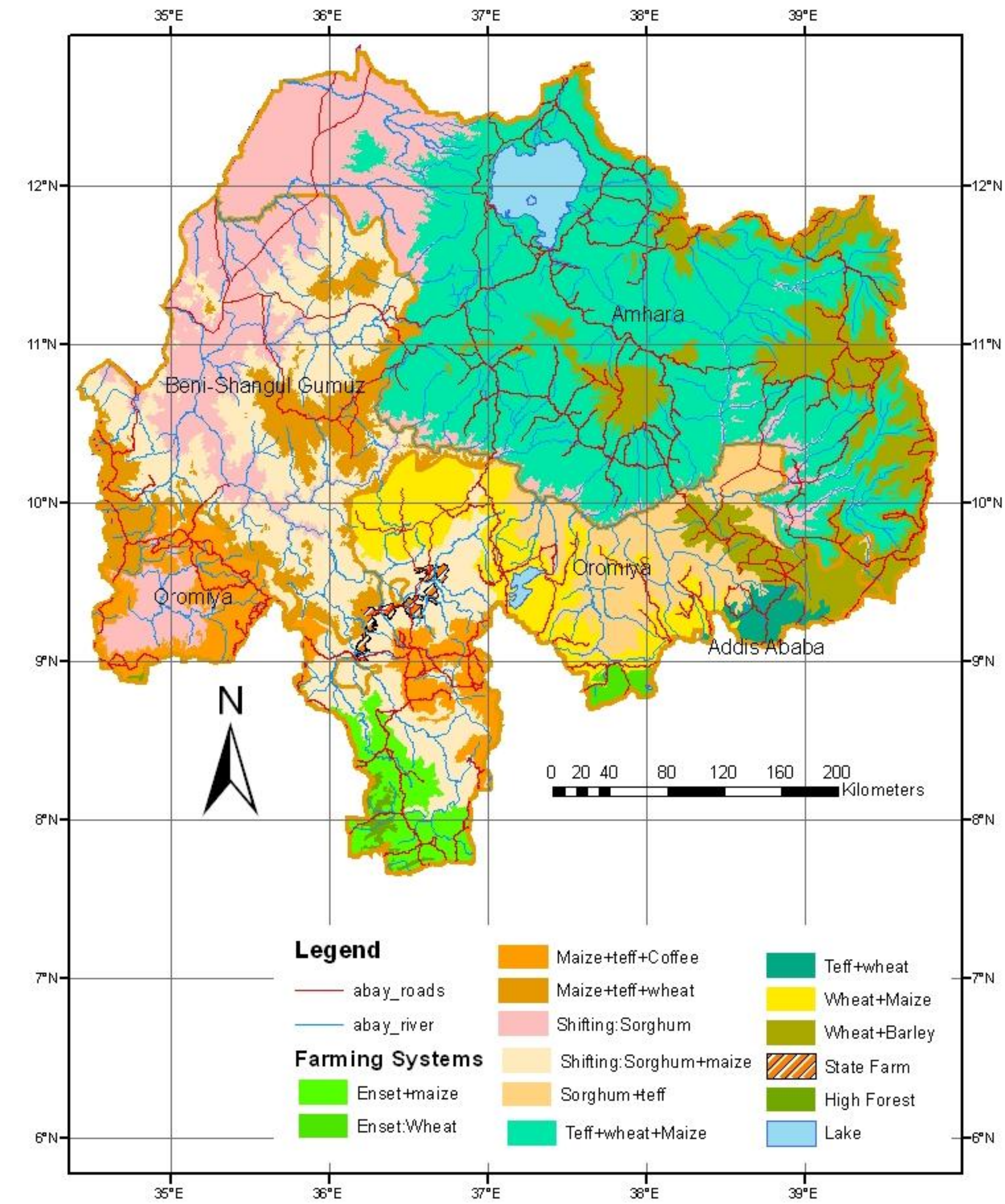

Figure 3. Abay Basin dominant farming systems
Source: Modified from Hydrosult 2006: 76, Map 15.

While these physically based zones are useful as broad tools for characterizing differences in potential and current cropping patterns, they are not adequate for targeting agricultural development investments in general or RWH interventions in particular. For example zones based on average rainfall and/or growing period do not capture rainfall variability; a revised map of the "Three Ethiopias" distinguishing "moisture reliable" and "drought prone" zones based on the coefficient of variation of rainfall, plus low rainfall pastoral areas, shows different boundaries. Combining these with elevation produces zones of agricultural potential that are again quite different (Chamberlin et al 2006: 23-26, including Figures 3 and 4). But these are still not adequate, as they do not capture other important dimensions such as access to markets; this is the basis for

applying the concept of "development domains[55]." Further, they do not take into account the availability of "blue" water: the driest areas often have major rivers passing through, and therefore have the highest irrigation potential.

Development domains

The concept of "development domain" attempts to refine the agro-ecological zone concept by measuring key factors that together define the main components of a region's development potential. Agro-ecological zoning alone is a basis for estimating theoretical potential but says nothing about the economic and demographic factors that would give the zone a comparative advantage in particular production enterprises. As developed by Chamberlin et al (2006), Pender et al (2006a, b), Kruseman et al (2006a, b) and others, it combines three factors: agricultural potential, access to markets, and population density. Agricultural potential is a function of an area's absolute advantage for production based on level and reliability of rainfall, soils, temperature and other bio-physical factors. Access to markets and population density together "translate absolute production advantages into comparative advantages for particular livelihoods" (Chamberlin et al 2006:15). Access to markets is closely linked to the costs involved in profiting from one's production. Population pressure is recognized as a key potential driver in agricultural innovation and intensification, though its actual impact varies: whether its impact is more 'Malthusian" or "Boserupian" is a function of market access and agricultural potential.

Chamberlin et al (2006) used a process of consultation with experts to define each of these domain parameters, arriving at two classes of market access and three classes of population density. They then tested these for their statistical validity. They found that most livelihood strategy variables were indeed significantly affected by agricultural potential, population density and market access, enabling them to classify *woreda*s and prepare a development domain map for Ethiopia (Chamberlin et al 2006:37-43 including Figure 7). Kruseman et al (2006a, b) note these are exogenous factors and add one more: socio-economic and institutional heterogeneity. They assess the degree to which investment decisions (especially for SWC-RWM), livestock use, technology choices, and cropping patterns are influenced by development domains in Tigray. They found that "agricultural potential" combines multiple variables that do not co-vary: soil quality and degradation, rainfall, altitude, temperature, etc. They also suggest that institutional support may be more critical than market access measured in the time it takes to travel to a town. Villages exhibit a marked variation when mapped according to measures of market access, population density, and various agricultural potential measures, which in turn has large impacts on investment and technology choices and wellbeing.

Some of the articles in Pender et al, eds (2006) as well as the Chamberlin et al (2006) paper test and largely confirm hypotheses about livelihood strategies in different development domains in the East African highlands including Ethiopia. For example, commercializing of high-value perishable crops is most profitable and feasible where there is favorable market access (and such areas tend to have high population densities). They are not appropriate in so-called "low-potential" areas far from markets; however, these areas may have a comparative advantage for cereals, livestock, or non-perishable easily transported cash crops such as cotton. In truth, the characterization of areas as

[55] Malesu et al 2006b provide a GIS-based methodology for mapping rainwater harvesting potential; Ethiopia is one of the case studies. This study is based on national mapping, too broad to be useful; however the methodology may be worth exploring further.

"high" or "low" potential is misleading; rather, the potential comparative advantage varies among zones and even within zones. The threat of land degradation, the need for better RWM and, attractiveness of investments in SWC-RWM all vary not only with agricultural potential but with market access and population densities. Population pressures are associated with the threat of land degradation through agricultural intensification, but the returns to investment in conservation vary with market access. In previous sections we have noted that many studies show positive returns to SWC investments such as stone terraces and reduced tillage in low-rainfall but not high-rainfall areas (e.g., Pender & Gebremedhin 2006; Benin 2006) but their economic returns are likely to be a function of market access and profitability of agriculture as well as rainfall patterns and soils.

We conclude therefore that the concept of development domains is a useful tool that can assist in choosing appropriate RWM action research sites, or in identifying the kinds of RWM investment most likely to be appropriate. For example, in areas far from markets, relatively low-cost and low-maintenance technologies, such as small treadle pumps may be effective, while more sophisticated equipment may be viable where farmers are growing high-value crops for the urban market.

8.3 SLM program targeting

SLM implementation programs in Ethiopia have historically targeted food-insecure areas, generally areas regarded as having low agricultural potential because of low and erratic rainfall, steep slopes and low soil fertility. These areas are frequently in need of food relief or emergency assistance as they are the most vulnerable; SLM programs have been directed at combating household level food insecurity while trying to reverse land degradation. The MoARD notes there has been and continues to be a lack of consensus on what constitutes a priority area for SLM; for example it notes the new World Bank SLM project is targeting "high potential areas" where current agricultural production and long term food security are under threat from land degradation; hence investing will produce high economic benefits. The MoARD has therefore developed a set of economic, social and environmental criteria that reflect the interests of various stakeholders. A priority ESIF area will be a *woreda*, village, or watershed where investment of scarce resources can be justified on the basis of the high value of public benefits (MoARD-SLM Secretariat 2008:39ff). These criteria are rather general and are not mutually consistent; however they do recognize that the previous targeting of low potential areas was too limiting. Under the largest component of the SLM Program – field based investments to promote and scale up SLM practices – one subcomponent promotes community-based participatory watershed management in high potential areas. The MoARD has identified 177 priority watersheds (ranging from 3215-16900 ha with 15-20 sub-watersheds each) of which the World Bank Project is targeting 35 (World Bank 2008a). Another sub-component targets food insecure areas with medium potential but threatened by land degradation. It accepts the economic returns will be lower but expects over the long term the investments will enable households to be food secure (Tana Beles IWRD Project is given as an example). The CPWF needs to take this targeting into consideration.

It is clear that there has not been sufficient research to be confident about the effectiveness of targeting investments in SLM – or for that matter RWM. Further, clear criteria for prioritizing both larger-scale watersheds and the micro-watersheds within them, in terms of upstream-downstream impacts as well as economic and social dimensions could be useful for targeting future investments. The development domain concept has not been applied to watershed prioritization: combining development domains with watershed conditions and opportunities may offer a way forward.

8.4 Concluding remarks

This section has identified many issues related to targeting of RWM investments. There is insufficient knowledge on how to target RWM investments effectively to poor women as well as men or targeting poor households more generally; and there is even less research-based knowledge on RWM outcomes for poor women and men. "Development domains" are helpful in classifying communities and the most appropriate interventions, but are not helpful in targeting relatively poor people; rather they focus attention on growth potential. Finally, the government is struggling with how best to prioritize and target its SLM program to watersheds where investments will have the greatest social, economic and environmental impacts; but has not considered combining watershed characteristics with other developmental criteria. A CPWF contribution to clarifying this with regard to RWM investments may be very useful in the long term.

9. Consolidation: What are the Main Lessons Learned?

The Challenge Program on Water and Food has chosen as its Nile Basin Development Challenge "*to improve rural livelihoods and their resilience through a landscape approach to rainwater management*." This paper has sought to critically summarize the main lessons learned from both implementation projects and past research studies aimed at improving land and water management in the Highlands of Ethiopia. The purpose was to integrate and synthesis the existing documentation and identify the major conclusions, lessons learned, and gaps in knowledge. This is expected to provide a foundation to inform the planning of the next phase of CPWF. The findings and observations may also be useful to other researchers as well as to policymakers and implementers. The analysis has taken a broadly historical approach, and has been guided by several concepts. One is the broad concept of "rain water management" adopted by the CPWF: RWM includes soil and water conservation, *in situ* and *ex situ* rainwater harvesting, conservation farming, and small-scale (i.e., micro) irrigation focused on livestock, trees and fish as well as crops. A *rainwater management system* (RWMS) therefore includes technologies and practices for managing water for production, and the policy, institutional and social dynamics and support systems necessary to optimize the benefits of such technologies and practices. This definition draws attention to the necessity of an integrated watershed management as well as "landscape" perspective: how people on a shared watershed manage their land, water and biological resources, at various scales from plot to farm to watersheds has critical long term consequences not only for themselves but for those residing downstream.

Another key concept is *water productivity*. The main objective of the CPWF is "to increase the productivity of water for food and livelihoods …." This perspective centers on management of water as the critical entry point for improving people's livelihoods. Over the past 15 years, researchers have found that measuring WP and finding effective ways to improve it are enormously complex system problems, which do not lend themselves to simple solutions. Ethiopia has been investing heavily in reduction of land degradation, especially water-related erosion in its highlands. Examining these programs through a water productivity lens has shown that far too little attention has been paid to improving management of water for sustainable production and livelihoods. Finally, in recognition that the old linear applied research-to-application model does not work well, especially in developing country agricultural development, this paper has tried to examine Ethiopian RWM experiences from an "innovation systems" perspective. An innovation system is a creative process

among a set of organizations and other interested parties with shared stakes but different roles in developing and using new technologies, institutional forms or practices. It therefore links policymakers, service providers, researchers, potential clients or users, and others in a process of mutual learning and innovation. An innovation system includes participatory research with farmers, building on their indigenous knowledge and experiences while providing opportunities to improve upon and complement them; but it integrates a wider set of stakeholders into the process.

This section synthesizes the main findings of the report. In the next subsection it tries to synthesize lessons learned from nearly four decades of experience implementing programs whose principle aim has been reduction of land degradation, with an emphasis on what works. It does not attempt to summarize the detailed findings reported in the paper, only selected key points. Subsection 9.2 summarizes the key outcomes of research on land and water management in Ethiopia, highlighting gaps in knowledge and the need for a paradigm shift in how research programs are designed and conducted.

9.1 From coerced land management to farmer-led integrated watershed management

The process of expanding cultivated area, reducing natural forests and grasslands, and intensifying grazing in smaller and smaller areas to accommodate a growing population has been underway in the Ethiopian Highlands for centuries. While there has been little productivity-enhancing technological innovation until recently, farmers did develop and use indigenous practices to minimize land degradation and maintain soil fertility. But by the mid-20th century, with increased population growth rates in a context of a political system centered on an emperor and a tiny elite controlling most of the land and other resources, the entire agricultural, political, economic and social system was losing its resilience. Periodic famines have occurred throughout Ethiopia's history, but extremely severe droughts and crop failures in the mid-1970s provided an opportunity for a new military regime (the *Derg*) to replace the old feudal system. It implemented radical reforms, especially nationalizing all land and setting up a system for periodic redistribution of plots among families, reorganizing rural institutions, and expanding support for agricultural development, emphasizing state-owned commercial farms and the collectivization of production systems among smallholders. However, famines continued to weaken the state, the state lost considerable international support as well as the support of significant groups within the country, and in the early 1990s it was overthrown and replaced by a new government. The current government has retained some of the previous policies, for example land tenure reforms and the emphasis on agricultural development, but has made major changes in their implementation. It also created a new decentralized federal government system under a new constitution, and has attracted high levels of support from the international community. The government has worked hard to develop new development policies, based on agricultural development as the main driver for achieving poverty reduction and economic growth. It is investing heavily in rural and urban infrastructure, and provision of basic educational and health services. Despite impressive achievements, and because of the extremely low starting point, Ethiopia remains one of the poorest countries in the world, and over 12 million people – in some years more – remain food insecure. Its agricultural productivity remains low, dominated in the Highlands where about 90% of the population lives, by low input-low output rainfed mixed crop-livestock production.

The crises of the 1970s and 1980s brought to the world's attention the rapid rate of land degradation underway in the Ethiopian Highlands. This degradation, coupled with nationalization of rural land and all privately owned commercial agricultural enterprises, and the infamous policy of forced collectivized production system and "villageization" came to be perceived as the root cause of low agricultural productivity and an existential threat to the future of Ethiopia. In the early to mid-1980s, two research programs were initiated to quantify the land degradation problem, understand its underlying dynamics, and identify measures to reverse it. Simultaneously, beginning in the early 1970s, food aid and relief efforts became directly linked to efforts to reverse land degradation through various food for work programs. This linkage has continued to date: FfW and recently cash-for-work programs have been used as a means to provide much-needed food aid to rural people, while also requiring them to earn the food through rural public works. These included building roads and public buildings; but a major component has been the construction of soil and water conservation structures intended to prevent or reverse erosion processes. More recent programs have widened this emphasis to include RWM ponds, wells, and diversion structures, biological as well as physical land management structures, and most recently, promotion of income-generating projects. The paper has reviewed the experiences of the major SWC-RWM ("sustainable land management" or SLM) programs in some detail; the next subsection synthesizes the major trends over time and the key lessons learned.

Lessons from implementation programs: What works and recommendations

Historically, the Ethiopian political system and culture has been authoritarian and male-dominated. It is therefore no surprise that the early SLM programs were driven from the top and often used coercion in various forms to meet quotas established at higher levels. Through these early programs, rural people created thousands of kilometers of stone and soil bunds, in some cases through "voluntary" community labor, and in others through FfW programs. While the food aid undoubtedly saved millions from starvation, the value of much of this "SLM" investment is questionable: when the *Derg* was replaced by the current government, a large percentage of these structures were deliberately destroyed. There continues to be considerable evidence that SWC structures promoted by government are often not perceived positively by farmers, usually for good reasons. There are many reported cases of inappropriate technologies being promoted in given conditions, and construction of structures that are then not used. For some years under the new government, however, the top-down food aid-driven programs continued, perhaps with less overt coercion, but driven to a large degree by food aid as an incentive, rather than by participants' recognition of the need for these investments. By this time, it is likely that some of the results of the early research programs, especially the Soil Conservation Research Project (SCRP) were influencing the specific technologies promoted (for example *fanya juu*), though they provided no guidance on implementation strategies. On the other hand, although on a limited scale, there is an excellent example of community-owned and managed SLM practiced by the Konso people in SNNPR. The Konso people have used traditional SWC conservation practices for generations, without interventions from the government, FfW, or NGO support. These have enabled the community to maintain the productivity of their agricultural systems on a sustainable basis.

It appears that evaluations of donor-supported government programs, combined with several bilaterally funded integrated rural development programs and the experiences of NGOs, all began to demonstrate the need for a new approach to implementation. The lead program in this process has been what is now referred to as MERET ("Managing Environmental Resources to Enable

Transitions"), a three-decade collaboration of the World Food Program and the Ministry of Agriculture and Rural Development. This program, complemented by others, began moving from a top-down implementation strategy to one that became more community-driven. It initiated and refined based on experience a "Local Level Participatory Planning Approach" (LLPPA) that enhanced the voice of community members in planning and implementing SLM programs. Based on this approach and other material, the MoARD produced the "Community Based Participatory Watershed Development" (CBPWD) guidelines in 2005 (MoARD 2005a, b). These have been widely disseminated and are now used as training and implementation guidelines in nearly all SLM projects. CBPWD is the basic guide for a new large-scale 15-year SLM program being implemented by government and its development partners. More recently, MERET and other programs have broadened their programs to include biological SWC measures, forestry and agro forestry, area enclosures to encourage regeneration of vegetation, and income-generating activities.

These changes demonstrate a commendable capacity for learning from experiences and changing approaches based on the lessons of the past. Nevertheless, many challenges remain. Although the guidelines and training programs emphasize "participation" of communities, it will take many years to change the dominant culture of government and indeed communities from an authoritarian to a democratic mindset. Establishing quotas from the top continues to be policy, and continues therefore to drive local officials' behavior as their performance is evaluated based on this simple-to-use monitoring tool. In some instances using FfW as motivation for SWC works may also be leading to a dependency mentality on the part of farmers. Capacity limitations both in terms of number of trained staff and the quality of the training, combined with logistical and other resource limitations, continue to have impacts. Rapid turnover of staff along with frequent institutional re-organizations are also common complaints. The performance evaluation problem could perhaps be solved by implementing performance assessments based on clients' feedback: if a watershed program is truly demand-driven, the community will make use of the expertise of the DAs and can assess the usefulness of the assistance received. This would also empower the communities, shifting the balance of power in their favor, and increase the likelihood of longer term sustainability. *We recommend pilot testing ways of creating client-based incentives to make extension staff more responsive to their clients*.

Another limitation is that some current SLM programs have not made a full transition from reversing land degradation as an end in itself to improving land and water management as means to increase and sustain productivity. It is true that MERET has widened its scope to include income-generation, and that rainwater harvesting technologies such as ponds and wells are now promoted by regional governments as well. But it is not clear to what extent these initiatives are integrated into the new SLM Program financed by the World Bank, GEF, IFAD and others. A major finding from both research and practical experience is that people are so constrained in terms of meeting basic short term consumption requirements that they cannot wait for benefits from SWC that accrue only in the future; they need immediate benefits. This would suggest that programs should focus even much more on providing the means for people to raise their productivity in the short run, while encouraging longer term investments that are complementary and phased in over time. Another problem with the focus on reversing land degradation as a goal is it fails to address the need to improve productivity of water as a complementary – perhaps even preceding – goal. Put differently, rather than seeking to reverse land degradation, which is a negative goal, *we recommend fully adopting a positive goal of assisting farmers to increase productivity sustainably as the driving force*.

In this context the lack of research on water management technologies and practices combined with the minimal integration of water management, land management, and management of livestock and agro forestry, and non-availability of low-cost equipment such as treadle and manual pumps, drip irrigation kits and small power pumps, are major impediments to progress.

A sustainable production goal draws attention to the need to strengthen the partnerships among farmers, extension staff, researchers, and indeed other stakeholders such as retailers of equipment. Many RWM programs have had mixed outcomes, not because the technologies were not useful but because of implementation weaknesses. Several evaluations have noted the lack of good advice to farmers on how to make productive use of water. It is also clear that implementation programs have not been sufficiently linked to research programs: there needs to be a synergy where research priorities are identified by the clients (farmers, implementing agencies, policymakers), research is carried out in partnerships among stakeholders, and results of research are absorbed quickly into the implementation process. The AMAREW project in Amhara sought to strengthen the farmer-extension-research linkages, using “farmer research groups” and other means; the project may not have continued long enough to have a lasting impact. But even this effort was too limited. Researchers have also identified a host of policy and institutional issues that affect adoption and continued use of SLM and RWM. *What is needed is a long-term strategy that offers communities a menu of practices and technologies, capacitates them to make informed choices and develop their own watershed management plans, supports them to implement these plans, and encourages a continuous process of innovation and sharing of new ideas*. In this context, we recommend a stronger focus on building community-based institutions to enable watershed users to take responsibility for managing their resources. Even a decentralized government cannot effectively manage small watersheds; their role should be to support and facilitate community management.

Finally, the national research system has for quite a long period of time been dominated by crop breeding and the identification of improved or new varieties, and soils research. As a result, support to natural resources research, i.e., land and water management and RWM, has been extremely limited. Natural resources management research capacity needs to be strengthened and modernized, including strong partnerships with clients. In addition, the government has been concentrating on the reversal of land degradation problems in drought affected and marginal areas while pushing use of improved seeds and fertilizers to boost production in some of the high potential areas of the country, with little regard for sustainable management and use of natural resources in these areas. This neglect has also contributed to the exacerbation of the problem and the continued shortfalls in overall food security.

9.2 Lessons to guide research: CPWF landscape approach to rainwater management

Gaps in knowledge

Several decades of research in Ethiopia have produced a large body of knowledge on land degradation processes and impacts, the performance of various land management and soil water conservation technologies, targeting of SWC interventions, the effectiveness of various implementation strategies, and the impacts of policies on incentives and productivity. However, the results reported from this research are contradictory, with, for example, some researchers reporting high returns from SWC interventions, and others reporting minimal or even negative returns. There

has been very little systematic comparative research on the diverse SWC technologies, their performance, the conditions for which specific technologies are most appropriate, and the accompanying crop, land and water management practices needed to enhance their productivity. If farmers continue to plow the land six times for teff, how does this affect the return on investment in terraces, for example? There is no research on the actual costs and benefits of maintaining various types of SWC technologies though these may be important determinants of farmers' willingness to sustain them. Nor has there been research examining the comparative performance of indigenous and introduced technologies, the extent of private investment and spontaneous outscaling, and what factors affect these. Finally, much research has focused on erosion control but far less has tried to identify how farmers can better manage soil fertility in a way that is both affordable and productive.

Water management practices and technologies, the multiple means to improve the productivity of water used by crops, livestock and agro forests, and the outcomes and social and economic impacts of these various technologies are not well-researched in Ethiopia. We have noted above the neglect of water management by both the international and national research organizations in Ethiopia. For example, we found no research studies examining the performance of and potential market for low-cost small-scale individualized water management technologies such as treadle pumps, drip and spray irrigation, and small power pumps. Similarly, while there is some research on the uptake, use and economic returns of RWM ponds and shallow wells (much of it reporting contradictory results), we found no research examining their water productivity and ways to improve their sustainability and productivity. Another important research gap relates to the interactions and synergies among diverse RWM technologies and practices: much of the research examines the performance of a single technology in multiple sites rather than the outcomes of a suite of practices implemented in an integrated fashion on a watershed. What would be the outcome of implementing with interested farmers an integrated multi-pronged program that combined physical and biological terraces, reduced tillage agriculture, agro forestry, *ex situ* RWH and shallow wells, regulated use of common grazing lands, and introduction of small livestock? And how can the potential for shallow groundwater use in small watersheds be identified cost-effectively, and how can its use be managed to achieve sustainable, equitable and productive outcomes?

Research on improving livestock water productivity is also in its infancy: while there has been useful conceptual work and some assessments of productivity under different conditions, to date there has not been any action research testing livestock management options, or the relative advantages of small versus large livestock, from a water productivity perspective. Similarly, while agro forestry has been identified as an important pathway to improved and sustainable water productivity, there is little research aimed at demonstrating how to achieve this goal. More broadly, there is very little research on how to achieve improved water productivity and (aside from some work on irrigation investments) on what would be the implications of achieving higher WP in terms of sustainability, poverty and food security impacts, and economic growth. Research on the impacts of upstream RWM interventions on downstream stakeholders and resources is also in its infancy.

There is also a need for more nuanced in-depth local level case study research on local cultural, social and institutional dynamics from a socio-technical perspective. Although policy and implementation rhetoric is participatory and gender-sensitive, the actual local political and social processes and their impact on who benefits and who does not from government programs are likely

to be at variance to the rhetoric; there is only a little research on this in Ethiopia, though it has been documented frequently elsewhere. For example, more often than not, well-intentioned "participatory" programs tend to exclude the poorest people, especially women, from both decision-making and sharing of benefits. Related to this, researchers have not examined actually program implementation processes and outcomes at local levels. We do not know enough about what actually transpires as the Productive Safety Net Program (PSNP), MERET and other programs are implemented, and therefore we are not able to advise effectively on strategies to improve targeting and effectiveness of such programs[56]. A broader point, related to the discussion of implementation experiences, is there have never been sufficiently strong linkages between SLM-RWM research and implementation programs in Ethiopia. SCRP was supposed to have such linkages but seems not to have been entirely successful on this point; and while the various CGIAR-supported research programs have had some links to policymakers, it has apparently rarely been sufficiently close and systematic to achieve the desired mutual impacts. On the other side, implementation programs have rarely included an applied research program integrated into the implementation process.

In view of the huge investments made in SLM and to a lesser extent RWM by various programs over the past few decades, it is a surprise that there has never been a systematic comparative evaluation and assessment of these interventions, their outcomes and achievements, and lessons learned to guide the future. Therefore, new programs often repeat the same mistakes as past programs, in terms of implementation strategy, promotion of inappropriate technologies, and insufficient attention to local level institutional capacity-building. Such an evaluation should take a watershed perspective, and examine for example downstream impacts of upstream conservation interventions and the distribution of benefits and costs.

Multidisciplinary participatory action research on RWM is incredibly rare in Ethiopia; to our knowledge the major exception was the African Highlands Initiative, but this was focused on how to promote collective action and on land not water management. Other programs such as AMAREW, the GTZ integrated food security project, and perhaps ILRI's Integrated Productivity and Market Support Program are partial exceptions. It is clear from this review that there is a need for scaling up RWM research, governed by a new paradigm. Section 10 offers recommendations for the next step in the CPWF Nile BDC program.

10. Recommendations for RWM in the Ethiopian Highlands

10.1 Elements of a new paradigm RWM research program

The CPWF recognizes that single-factor interventions, whether they are SWC structures, RWH practices, or improved livestock management, may not by themselves lead to optimum outcomes. Therefore it has designed phase 2 as an integrated watershed or "landscape" program. As explained in section 1, there are four action research projects focused respectively on: 1) integrated rainwater management strategies integrating technologies, institutions and policies; 2) targeting and scaling out; 3) assessing and anticipating consequences and outcomes of innovation, for example downstream externalities; and 4) coordination and multi-stakeholder platforms aimed at ensuring synergies among the CPWF projects, using outcome logic models to provide strategic guidance on

[56] Segers et al (2008a, b) is one of the few exceptions; as is Teshome (2003) for SSI, both in Tigray. However, while offering critical insights, neither offer significant solutions to the problems identified.

achieving impacts, fostering change through mapping and engaging with RWM actors, and promoting communication and sharing among RWM researchers, policymakers and implementers. The latter project also promotes capacity building and gender mainstreaming. We suggest that these projects constitute the potential elements of a participatory innovation system research and development program, but they require some important adjustments. These are discussed under six headings[57].

1. Innovation system including multiple stakeholders

The CPWF proposes to work with other researchers as well as policymakers, development actors, and of course farmers. Working with and through national and regional research institutions and universities is critical and is part of the plan[58]. But we suggest the CPWF should cast its net wider, and include, at multiple levels, other actors. At local level, small agro-business people, traders, health specialists, and religious leaders could be included in addition to NGOs and government officials; some will play passive advisory roles; others may wish to be actively involved. Examples include identifying options for research, pathways for scaling up and out, and implementing research activities. At regional and national levels, CPWF should actively involve key agri-business people (on both the agricultural services and input supply side and the agricultural produce demand side), policymakers, researchers, middle-level officials (representing the future policymakers), development partners, consulting firms, and NGOs. This "involvement" should go beyond periodic "consultation" through occasional workshops and include invitations to participate actively in the entire research process. It is especially important to engage with the leaders of RWM-SLM investment programs: these are likely to be major sources of suggestions on knowledge gaps, and the major pathway for uptake of new research findings. Such a wide-ranging intensive and active engagement should enhance the potential innovativeness of the research program, increase the likelihood of buy-in and longer term support, and result in beneficial spin-offs, for example more private sector initiatives in scaling out new technologies. It may also lead to higher levels of demand for both applied research services and the products of the research.

2. Farmer-driven participatory innovation development

It is often claimed, incorrectly, that Ethiopian agriculture has failed to innovate spontaneously for higher productivity, reflecting an assumed conservatism and reluctance to change on the part of Ethiopian farmers. This is not the case, as experiences such as SG 2000 with promoting modern maize and wheat production, has shown: when the benefits are clear with good market access, Ethiopian farmers respond. There is also, however, the question of farmers' own innovativeness. In recent years there have been a number of small-scale programs to enhance and strengthen local-level innovation processes and harness the dynamics of local knowledge by identifying local innovation processes and supporting farmer creativity (e.g., Jonfa & Waters-Bayer 2005; GebreMichael & Waters-Bayer 2007; Waters-Bayer & Bayer 2009; Abay & Gebregiorgis 2009; Prolinnova 2009). The participatory IWM program implemented under the African Highlands Initiative had similar experiences (e.g., Amede et al 2004, 2006; German 2006; German et al 2007).

[57] Tress et al 2007 discuss the potentially formidable barriers to successfully achieving integration in landscape research projects, for example the additional time needed for integration and difficulties in agreeing on a common problem definition. The subdivision of the CPWF Nile program into separate projects may prove a danger.

[58] In our interviews we were left with the impression that EIAR feels it has not been sufficiently involved but this will presumably be corrected.

Such participatory innovation development goes far beyond the "normal" participatory action research where farmers agree to try something on their fields proposed by researchers; rather it engages farmers fully as partners, co-equal sources of ideas about innovations as well as partners in implementing and evaluating the results and then communicating them. Such a process can be used to develop and test institutional as well as technical and management innovations. But it requires considerable personal skill to establish this kind of working relationship with farmers, and of course farmers living on the edge of subsistence do not have much time or other resources to devote to research. It will require identifying those farmers who already have a passion for trying new things and working with them to enhance their effectiveness. We suggest it may be valuable to engage with and seek to influence existing farmer participatory innovation development programs as a way to scale out testing of innovations. The "farmer participatory consortium model for integrated watershed management" developed by ICRISAT and partners may be an interesting model to adapt (Wani et al 2009).

3. Integrated synergistic multiple interventions

Too much past research has focused on single system components, such as technologies or institutions, rather than on watersheds as complex systems. But the complexity of agro-ecological systems is one of the main stumbling blocks to scaling out innovations to improve the effectiveness of water management (Huppert 2008). Watersheds may be conceived of as open complex adaptive systems (Hall & Clark 2010), i.e., they are "systems" because of the interconnectedness of their elements (physical, biological, climate, humans, information, etc), such that they cannot be defined or understood solely in terms of their component parts. Therefore, their dynamics must be understood in system, not elemental, terms. This concept underlies the "landscape" approach proposed by the CPWF and the LWP model proposed by CPWF researchers discussed above. In terms of interventions, Huppert (2008) makes an important distinction between systemic and non-systemic interventions. Systemic interventions are those that must take account of the complexity of the system, because they will interact with other system elements in complex, often unpredictable ways, and may be transformed or rejected as part of this process. Non-systemic interventions are those that are simple enough that they have no transformative systemic interactions. Most RWM innovations are likely to be systemic. As a result, seeking to maximize returns from one element (say, crop yield in a season) may have unintended, possibly deleterious impacts on the system as a whole (for example soil nutrient depletion). On watersheds, RWM interventions in the upper watershed are likely to have important impacts in the lower portions of the watershed; for example the benefits of SWC may be far higher for downstream stakeholders than for those implementing them upstream; or water capture and storage interventions may deprive downstream people.

Therefore, rather than promoting short term gains in one element, it is critical to examine how to introduce innovations that will increase the capacity of the system to produce a range of outputs in a way that does not threaten its integrity or lead to inequitable sharing of benefits and costs. This creates a dilemma in the Ethiopian Highlands since the central elements of the system — human beings – face serious consumption challenges and are therefore often forced to adopt survival strategies that threaten the long-term integrity of the system. It may therefore be essential to provide additional exogenous support and incentives over the medium term to enable people to move the system to a more sustainable and productive level. An example is payment for environmental services (PES) as there are substantial positive externalities and public goods resulting

from improved upper watershed management. It may also be possible to identify a set of interventions that, in sequence, move from achieving higher short term productivity to meet immediate needs to longer term evolution of the system to enable optimizing outputs at the system level. Participatory modeling and GIS are tools that can assist in identifying opportunities, and enable people to visualize trade-offs and potential synergies among interventions.

4. Examination of local social and economic dynamics

A critical subsystem of watershed-based agro-ecological systems is the human socio-economic system. The productivity of water and other resources and the distribution of the costs and benefits of exploiting them are ultimately a function of the effectiveness of policies and institutions. And in most watersheds, collective management of resources is a necessity for long term sustainable production. However, conceptualizing this system is not straightforward and social scientists have highly contentious debates on this. A relatively straightforward approach is to adopt an institutional economics perspective. Proponents of this approach have attempted to identify basic rules and "design principles" that are seen as universal and provide a basis for designing, "crafting," and even "engineering" institutions. The notion that one can use universal design principles to create institutions, rather like designing a building, is attractive. Unfortunately it is misleading and impractical because, among other reasons, it oversimplifies human motivations. An alternative approach can be built around a more contextualized concept of institutions and organizations that recognizes they are inherently political, socially embedded, complex and unbounded, with actors playing potentially creative roles but driven by a complex mixture of conscious and unconscious goals, not all of them consistent with the single-minded "rational" principles of institutional economics. This perspective is summarized under the term "institutional *bricolage*". Change agents are do-it-yourself handy men, *bricoleurs* and not social engineers. *Bricoleurs* improvise and borrow bits and pieces from multiple sources to create innovations, while engineers solve problems by applying scientific principles to design solutions. Social and institutional change occurs through the same creative non-linear process, driven by creative human agents with complex goals (Merrey & Cook 2010). Rather than attempting to graft a new kind of institution into an existing socio-economic-technical system, encouraging *bricolage* processes has the advantage of building on indigenous institutions, but modifying and adapting them, grafting new ideas (for example women representatives) into older ways of doing things[59].

We have noted in the previous section how little research has been done on local social, political, economic and cultural dynamics and their integration into management and adaptation of technologies. This is a serious gap in knowledge that limits our ability to effectively promote RWM innovations. Local power relations largely determine what interventions may be adopted, who benefits, and who pays the costs. Those who are poorest, with the least power and influence, for example landless people – the people most in need of support – may or may not benefit; but they surely will have no voice in the decision-making. The powerlessness of women is worsened by cultural values limiting their roles in public life and restricting their productive activities. Some innovations may make their situation worse, for example by adding to their workload, even if they lead to higher overall (system) productivity. We therefore need more in-depth studies of local social, gender and institutional dynamics as a basis for identifying and promoting innovations that

[59] Merrey & Cook 2010 is a draft paper for a CPWF basin focal project edited book. It sets out the concept of institutional *bricolage* in detail, with examples drawn from CPWF river basins.

are productive and equitable. An effective integrated landscape approach to watershed management must include attention to *all* stakeholders, not only those farming their own holdings.

5. Testing and assessing institutional and implementation innovations

A major finding of many of the research papers reviewed here is that the absence of strong, effective and appropriate policy and institutional incentives is a major deterrent to adoption of better water and land management practices. Economists have documented the lack of credit facilities to finance RWM improvements, inadequate access to functioning input and output markets, and insufficient access to information and knowledge. This suggests that far more attention needs to be paid to improving the policy framework and institutional capacity for implementation. Complementary to this, we also suggest that there needs to be more testing and evaluation of potential institutional innovations, adapted to the Ethiopian Highland context. Examples that have been suggested by others working in Ethiopia include payment for environmental services (PES) (Alemayehu et al 2008). Recent reviews of international experiences with PES highlight both the complexities and the potential benefits. For example, Milder et al (2010) estimate that by 2030 markets for watershed protection could benefit some 80-100 million low-income households globally and therefore contribute to poverty reduction (see also Porras et al 2008 for a review of experiences). Other potential institutional innovations include providing weather index and indemnity insurance (Meherette 2009), and using "interlinked contracts" to create positive incentives for investing in water and land management (Siferaw & Holden 1999). For those farmers selling produce into the markets, inventory credit systems such as those being tested in West Africa could be considered (Tabo et al 2009).

In addition to these, far more work is needed in partnership with farmers to identify ways to strengthen collective management of common property resources and make them more inclusive as well as more effective in management watersheds. This work should build on both indigenous arrangements (such as the *Qero* system where it is still in effect) and promising efforts to introduce new institutional arrangements like Community Watershed Management Organizations. An especially problematic area is management of protected common grazing and woodlot areas: indigenous institutions could be strengthened in some cases, while in others the emergence of new institutional arrangements may need to be supported. With the emergence of water as the key entry point in watersheds, there is also a need to explore new institutional arrangements for watershed management, through which all stakeholders from the top to the bottom of watersheds – including watershed resource users and local government representatives – can work out how to share the benefits and costs of introducing innovations aimed at sustaining and improving the productivity of land and water. We stress here, based on global experiences, that government cannot manage small and medium-sized watersheds effectively. It can however play a critical role in facilitating, encouraging and supporting watershed user-based management institutions.

Finally, because questions have been raised about the impacts of Food for Work on long term incentives, another promising area is to identify either alternative implementation strategies that could be used in areas where food aid is less critical, or alternative ways to provide FfW. In high-potential areas FfW is not necessary in any case, and to the extent possible even in drought-prone areas FfW and IWM should be delinked. Examples include linking IWM to the government's land certification program, and tying payments to the community to completion of specific targets agreed by the community and implementing agency, provision of community benefits rather than private

rewards, and prizes for community innovations and watershed systemic improvements. These are simply illustrative examples; the point is not to impose new institutional arrangements; rather, it is to engage with watershed users to catalyze and support creative institutional *bricolage* processes.

10.2 Research on under-studied topics

The government has recently adopted a focus on water as the entry point to raise agricultural productivity ("water-centered agricultural growth"). Such a focus is very welcome, but needs effective research support. In this context, the potential list of topics requiring more research is endless; therefore we do not try to propose a comprehensive list. We also avoid repeating suggestions made elsewhere. This subsection identifies additional topics that have struck the authors as being worth more attention, whether by CPWF or other research organizations such as EIAR, regional agricultural institutions and universities. They are listed with minimal elaboration.

1. Basic in-depth case study research on the evolution and trends characterizing small and larger watersheds from an integrated agro-ecological perspective, complementing existing Ph.D. studies identified in this paper. This work should be complemented by more long term interdisciplinary research on upstream-downstream processes and interactions on both small and large watersheds, building on the recently completed CPWF project. Within this context, test and adapt models that can be used for identifying outcomes of potential interventions as planning and monitoring tools. GIS and remote sensing are becoming increasingly accessible and affordable but remain under-used; for example a study of irrigation scheme productivity in the Nile Basin supported by EWUAP demonstrated how much can be learned through using such tools to assess evapotranspiration (Bastiaanssen & Perry 2009).

2. River basins and watersheds at various levels are emerging as key planning and implementation units. Studies of alternative institutional arrangements and processes for integrated management of river basin resources are needed, especially given the complexities and challenges of the Nile Basin. Such arrangements need to be nested, i.e., institutional arrangements at the level of small watersheds nested into larger frameworks (for example federations of CWMOs); they should provide mechanisms to reflect and where feasible give priority to local needs as long as they do not reduce benefits elsewhere. Such studies should identify the optimum roles of *woreda*, *kebele* and community level institutions and adjustments or innovations that may be needed. Alternatives to the normal international models of river basin organizations are needed, for example developing from indigenous roots (Merrey 2009).

3. We noted above that there are indications government may give greater emphasis to water management as a development entry point. In view of this, it would be timely to re-examine the current institutional arrangements for land and water development and management; for example the MoWR and MoARD do not have a defined mechanism for collaboration. Therefore a study should be proposed and if accepted implemented in collaboration with the government to address two related issues: the institutional arrangements for integrated water and land resources management; and adjustments needed in the existing water and land policies to ensure effective implementation. This should include development of a "green water" or "rainwater management" policy integrated with the "blue" water policy,

and an implementation plan complementary to the policies and strategies for sustainable land management, water development, and other governing policies. Hagos et al (2009) has noted there is currently no green water policy; in many cases watersheds are characterized by the full range of green to blue water. We would add there is also no IWM policy in place.

4. In the previous subsection we noted there has never been a systematic in-depth authoritative comparative study of the implementation strategies, effectiveness, impacts, outcomes, and lessons learned from the large number of SLM and RWM programs implemented in the last two decades. We recommend that the government should commission such a study. Its findings could be extremely useful in designing future RWM programs.

5. Detailed definitive and authoritative comparative assessments are needed of poverty outcomes, returns on investments, and sustainability of alternative RWM technologies and practices, and the interactions among them in watersheds. This study could also assess the effectiveness of targeting, for example of women and poorer households.

6. As noted previously, there is currently no systematic research on the impacts, outcomes and effectiveness of water lifting and water application technologies (i.e., treadle and power pumps, low-cost drip and sprinkler irrigation kits) and their potential future market.

7. We found very little information on the effectiveness of NGO programs in SLM and RWM. While the general assumption is they are relatively effective, there is no evidence this is the case. A part of such a study should also explore how to create better synergies and sharing of lessons between official and NGO programs.

8. Finally, there have been and continue to be many international and Ethiopian research organizations working on topics related to RWM. However, there has been no research on how effective they are in terms of impacts on technologies and practices adopted by farmers, policies, and implementation strategies. We do not have systematic information on how effective is collaboration between international, national and Regional research institutions and universities, or guidelines on what could be done to improve their effectiveness in terms of quality of outputs and value of impacts. Research on research may have very high payoffs in terms of understanding what kinds of research programs are most effective and have the highest returns.

10.2 Concluding remarks

We believe that Ethiopia and its development partners have invested more in improving water and land management (RWM) than any other country in Africa. It probably ranks third, after China and India – far larger countries. This demonstrates the vital importance and priority given to RWM. Over the past three decades, Ethiopia has adapted and improved its policies and implementation strategies based on lessons learned and to some degree the results of research. It has adopted participatory approaches, a livelihood focus, and an integrated watershed management paradigm. The combination of the launch of new programs such as the SLM Program, an increasing awareness by the government of the need to use water more productively (captured in the term, “water-centered growth”), and the launch of the CPWF Nile Basin Development Challenge (NBDC) initiative offer significant opportunities to create a new

paradigm for sustainable land and water management. Our most important recommendation is that Ethiopia should now take the next step and focus on supporting community-based watershed management institutions. To be successful, there is a need for researchers, especially the NBDC program, to work with communities to test and promote institutional and technological innovations on watersheds. The government needs to strengthen policy support for sustainable demand-driven research-based rainwater management programs.

This paper was prepared to answer three broad research questions complemented by more detailed and specific ones (section 2.3 and Box 1 above and Annex 1 below). The basic goal was to identify what is known from past experience about designing and implementing successful rain water management programs in the Ethiopian Highlands (both developmental and research and development programs), what is known about targeting them spatially, and who else is working on rainwater management and how can linkages be created. With hindsight we have succeeded in documenting knowledge from past experiences with SWC and RWM programs. We have contributed to but not been able to fully answer the question on spatial targeting; while text books can provide guidance on which specific SWC technology is appropriate for given conditions, not enough is known about spatial targeting of suites of RWM practices and technologies. We have identified numerous potential partners in sections 4-5 and especially annex tables 6-7; we leave it to the CPWF project leaders to follow up. Additional questions were subsequently suggested by CPWF project leaders on upstream-downstream linkages and analytical tools and models; we were only partially successful in addressing these.

However, we believe this paper has identified many important opportunities for introducing and scaling out and up RWM innovations based on lessons from past programs. We have also made some suggestions on the design of the second phase CPWF research and for other research needs. RWM innovations by themselves are not a panacea for Ethiopia's complex challenges. But they are undoubtedly a necessary component of the larger set of solutions.

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Note: This list follows western convention of using the surname followed by first initial. Ethiopian convention is to use the full name, so where confusion may arise, we do this selectively. The notations of date plus 'a', 'b', etc in some cases refer to those in Annex Table 1.

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